THE WESTERN SOCIETY OF MALACOLOGISTS

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THE WESTERN SOCIETY OF MALACOLOGISTS

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WESTERN SOCIETY OF MALACOLOGISTS
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Abstracts and Papers from the 34th Annual Meeting of the Western Society of Malacologists held 20-24 June 2001 at the Ramada Inn and Conference Center, San Diego

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REPORTS OF SOCIETY BUSINESS

Abstracts and Papers

The secret lives of sea slugs

Mary Jane Adams

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I have been diving and photographing marine life in the tropical Indo-Pacific for the past 25 years. Opisthobranchs are my favorite invertebrate group. By observing and photographing them in their natural surroundings, I have discovered some of the secrets of their lives.

Grazing rates and growth of postlarval abalone (*Haliotis* spp.)

Ricardo Searcy Bernal and Casandra Anguiano Beltrán

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Grazing and growth rates of *Haliotis fulgens* and *H. rufescens* postlarvae feeding on the benthic diatom *Navicula incerta* were studied experimentally. Postlarvae of different ages (2-60 days) were introduced in 10-ml sterile plastic dishes previously inoculated with the diatom. After 2-3 hours, video recordings were taken to estimate postlarval size and grazing rates by digital image analysis. Seawater was changed every other day and postlarvae were measured again after 6-8 days to estimate growth. Grazing rates were affected by several factors, including postlarval age, diatom density and starvation. The relationship between grazing and growth rates is discussed and preliminary efforts to model the postlarvae-diatom system are presented.

A brief description of the life and scientific contributions of Dr. Frank Mace MacFarland (1869-1951)

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Today we are honoring Frank Mace MacFarland 50 years after his death. It is only fitting that a few historical comments be made about the life and times of this man. He had a wide knowledge of history. With modern studies attempting to reconstruct the phylogenies and evolutionary histories of various opisthobranch lineages, he would be especially pleased and recognize the significance correlating the lives of those doing science and the lives scientists are studying.

On a Wednesday afternoon some sixty years ago, an announcement was made concerning a talk given in the Simson African Hall of the California Academy of Sciences. It reads, "Gold, gambling, and gaiety were only part of the San Francisco scene in 1853. It was in that year that a society for the promotion of science was organized by some of the leading citizens. Dr. MacFarland has made a special study of these historic days, and speaks with authority on the men who founded the Academy, and about the early history of the oldest scientific institution in the West". His life tied together the major centers of marine biology in central California: Stanford University, Hopkins Marine Station, and California Academy of Sciences. But we get a bit ahead of ourselves in our biography of the man once called an "extraordinary raconteur".

A week ago, prior to these meetings, I spent several days looking through the archives of the library of the California Academy of Sciences (CAS) for information on the life of Frank MacFarland. There was a curious paucity of information. I wanted to find a list of when, where and whats, collecting trips, vacations, photographs, etc. These were not there. However, the MacFarland papers at Standford contain correspondence with various individuals, sketch books of Olive, and MacFarland's log of bicycle trips around Stanford, San Jose, the Monterey Peninsula, and the California coast. They may have more.

In the CAS archives I found ten photographs of Dr. MacFarland. The best biography is still represented by the pages written by Robert C. Miller and printed in MacFarland's posthumously published "Studies of Opisthobranchiate Mollusks of the Pacific Coast of North America". Among the material were sheaths

of old bills. Some were mundane such as a night gown for $1.35, andirons for $6.75, Sanitol powder (tooth) for 15 cents, Mrs. Huttermann $1.65, chocolate 10 cents, one loaf of bread five cents, and three pounds of coffee one dollar. Others were lists of books bought from a European firm.

Among the papers in the CAS archives were numerous letters to Dr. MacFarland. Most impressive was a collection of the original water colors that Olive had completed for the 1966 manuscript and also original drawings for other publications by MacFarland. Terry Gosliner and I perused these exquisite drawings – pausing over the page of *Dendronotus* species, and aweing at the incredible blue tints she painted for Plate 24 of *Chromodoris californiensis* and *Chromodoris porterae* (respectively placed today in the genera *Hypselodoris* and *Mexichromis*).

Several huge rolled documents were also intriguing – the original diplomas of Frank MacFarland. They were huge, and of course in Latin. It took a few minutes to find De Pauw among the elegant 1889 script.

<u>Biography of Frank MacFarland</u>:

Frank Mace MacFarland was born on 10 June 1869 in Centralia, Illinois. His parents were Dr. Parker M. MacFarland and Sarah Mace MacFarland. He received his bachelor's degree from De Pauw University in 1889, and was shortly afterwards appointed professor of biology and geology at Olivet College in Michigan. Some of the photographs extant in the Academy's archives date from this period.

He was invited to Stanford University as an instructor in histology in 1892, just one year after it was founded. He received his master's degree in 1893; his diploma is signed by David Starr Jordan (who had actually originally asked him to come to Stanford). He then left for Germany for his doctorate. He studied at the Universities of Würzberg, Freiberg, and Zurich, with his Ph.D. being earned at Würzberg in 1896. I suspect that his publication "Cellulare Studien an Mollusken-Eiern" in the Zoologischen Jahrbuchern, was based on his doctoral work. The material for his study on eggs and chromosomes had been collected during the summers of 1893 and 1894, and then histologically studied in the winter months of 1894-1895 and 1895-1896 in Germany.

There is a bit of confusion as to when he met Olive Knowles Hornbrook, who would become his wife. The published version of Miller's biography says "while visiting in Indiana", but in an original typed version on file in the archives, that part has been corrected in pencil to read, "while visiting relatives in West Virginia." Well, the states are close! Regardless, they married in 1902.

MacFarland became Professor of Histology in 1909, a position that he held until his retirement in 1934. He helped establish the Hopkins Marine Station at Pacific Grove, and was its Co-Director from 1915 to 1917. An obscure publication in the Journal of Applied Microscopy and Laboratory Methods by MacFarland described the planning phases, structures, amenities, courses and professors at the Station, with photographs of the original buildings and coastal scenes. In the session of 1901, his friend George Price taught general zoology and embryology; MacFarland taught Comparative Morphology and Histology of the Nervous System and Sense Organs, and Advanced Invertebrate Zoology, and J. Grinnell taught General Ornithology.

Upon retirement from Stanford, MacFarland moved into the Presidency of the CAS, serving in this role until his announced retirement in 1946. There are dozens of congratulatory letters to MacFarland on this event. Perhaps most appropriate was the paragraph in the Academy News Letter of March 1946: "Many men have retired to go big game hunting. Nothing so commonplace can satisfy Dr. MacFarland. He has retired to hunt opisthobranchs, a group of delicately beautiful and inadequately known Mollusca, on which he is writing a monograph. By the time this appears in print, he and Mrs. MacFarland will be somewhere along the coast of southern California, hunting their elusive prey at each low tide".

MacFarland's association with the CAS continued after his retirement, serving as a sort of elder statesman. One morning he came to the Academy after having been absent for a while due to an illness. He walked over to the new building he had been instrumental in helping plan. Robert Miller states that he viewed the new exhibit halls and planetarium, talked with the preparators installing exhibits, and then went to the library to look up nudibranch references. Later in the day, he walked across the courtyard with Earle G. Linsley to attend the 97th Annual Meeting of the Academy, and collapsed and died at the entrance of the new building. In the introductory paragraph to "A new west American nudibranch mollusk", in which was described *Platydoris macfarlandi,* G. Dallas Hanna wrote, "A few minutes before Dr. F. M. MacFarland collapsed on February 21, 1951, he discussed with me the generic position of a rather remarkable species of nudibranch which had been collected a few weeks previously. He unquestionably would have described this animal in his very thorough manner had fate permitted. As a poor substitute, I will endeavor to place it on record and it seems fitting that it be named for him".

<u>Bibliography of Frank Mace MacFarland</u>:

Between 1897 and 1931, Frank MacFarland published nine papers on opisthobranch molluscs. A good 20

years passed between his last publication and his death. His monograph on opisthobranch molluscs of the Pacific coast of America was published posthumously under the guidance of his wife Olive. There is a lengthy correspondence in the archival papers between Olive and various individuals regarding the writing of this work. She consulted specialists in Europe on taxonomic questions, and had significant help from Rolf Bolin and G. Dallas Hanna. Contrary to Frank's correspondence, copies of Olive's letters are maintained, in addition to the responses from the people whom she wrote. Frank MacFarland also published several other papers: the description of Hopkins Seaside Laboratory (mentioned above), two papers on histology and microscopical technique in the Journal of Applied Microscopy and Science, respectively, and an obituary notice regarding Edwin Chapin Starks which was published in Science. The latter publication is especially poignant in view of that magazine's refusal to publish an extended notice of MacFarland's death. A copy of the letter from the Chairman of the Editorial Board of Science is in the Academy archives, and it reads, in part, "I am sorry to report that my colleagues [on the editorial board] are opposed to the publication of an extended notice under the conditions with which we are confronted. We are receiving more than twice as much material as we can print and are compelled to reject some of the manuscripts that we would like to include in Science. You may have noticed that during the past year we have published a diminishing number of obituaries, and during the past months we have tended to limit it to foreign scientists who are not known to American scientists as are people like Dr. MacFarland".

<u>Letters in the Archives</u>:

There are numerous handwritten or typed letters in the CAS archives from people such as W. H. Dall, Pilsbry, Odhner, O'Donoghue, William Ritter, and Cockerell. There is also lengthy corespondence from Barton W. Evermann of the Bureau of Fisheries in Washington D.C., regarding the publication of MacFarland's manuscript of the dorids of Monterey Bay. The latter paper was actually published twice; first, as a preliminary report naming the species, and second in full text with exquisite color plates and detailed anatomical drawings. MacFarland had been in correspondence with Cockerell and knew about the imminent publication of the Cockerell and Eliot manuscript "Notes on a collection of California nudibranchs". MacFarland wanted his manuscript published more quickly than the Bureau of Fisheries could do so, and Evermann guided him through the process of having the Biological Society of Washington publish a preliminary manuscript, prior to the full paper. Evermann detailed how to apply for membership in the society, and kept Frank appraised of when his membership application would be accepted and when the publication process could begin. These letters certainly make interesting reading, and I will highlight four of these below.

On 26 September 1901, T.D.A. Cockerell wrote MacFarland from East Las Vegas, New Mexico: "I am sending in the *Chromodoris* paper, following your kind suggestion. I have taken the great liberty of changing *C. angelicus* to *C. macfarlandi*, which I hope you will forgive. It is a very pretty species, and may be allowed to commemorate your work. Also, since one species is dedicated to U. of Cal, another may as well be connected with Stanford".

The only personal connection I know of between MacFarland and a member of the Western Society of Malacologists is in a letter dated 30 January 1946, from 2435 Bancroft St., San Diego. William K. Emerson writes MacFarland, "I have an unidentified nudibranch which neither Dr. M. E. Johnson nor I have ever seen before...All of them were found on a hydrozoan along with what appears to be their egg masses in Mission Bay. Would you care to identify them for us? I would be glad to send all or part of them to you. However, I am anxious to retain some of them for my personal collection. To introduce myself, I am a Junior at San Diego State College, majoring in invertebrate Zoology. My special interests are Mollusca and Echinodermata". Recall that thirty-four years ago Bill Emerson was one of the Charter Members of the Western Society of Malacologists.

In late July 1945 MacFarland wrote two European colleagues, whose responding letters are on file in the CAS archives. Both detail wartime conditions, from a slightly bourgeoisie perspective. Alice Pruvot-Fol wrote: "My family and myself have not too much suffered by this war; but of course many things are changed, and life has become difficult. Many of our friends have suffered from losses: an only son, 19 years old, shot by Germans; others come home with complexion so much changed that you could not know them by sight – an old friend of mine, suffocated to death in a waggon holding 200 men – meant for Germany, only because he was once Professor in Strasburg – and so forth. My sons are married. My daughter shall marry soon. We have now enough bread and vegetables, no tea, no coffee, no chocolate and very, very little meat. And we can buy no clothes and no shoes without great difficulties. I am not altogether stopped in my studies, but I am obliged to do all the housework and cooking etc., because very little people can afford keeping and especially nourishing servants".

Photographs on opposing page (clockwise from upper left): (1) portrait by Boye,1935; (2) in the intertidal zone at Chinatown Point, Monterey Peninsula near Hopkins Marine Station; (3) George Price and MacFarland (on right) in Palo Alto rooming house, late 1890s; and, (4) portrait, June 1898.




A lengthy letter from H. Engel on 24 August 1945, states in part, "My wife died, alas, in the second year of the war, but she was ill when it began. Perhaps you remember the bombardments of the Fokker Manufacturies. These were only 500 m from our home, but we got no damage, the nearest bomb was about 200 m and demolished some houses but we got through safely. The last months were the worst. Yet the Museums and Libraries were on the whole left untroubled. The Huns had the bad taste to make their headquarters in our most beautiful buildings. So the Colonial Institute and Museum was headquarters to the S. S. and if there had been fighting here in Amsterdam it would all have been burned down and bombarded – but happily the Allies tactfully knew to avoid war in the thickly populated western part of Holland. How thankful we all are for this, is not easily said!".

<u>Letters of Condolence</u>:

There were only a few letters of condolence in the archives to Olive MacFarland upon the death of her husband. Two were from the European friends with whom Frank had corresponded at the end of World War II, Alice Pruvot-Fol and H. Engel. The letter from Alice of 23 April 1951, reads, "Dear Mrs. MacFarland, How very sorry I am to hear the bad news your letter brought me! Last summer I had a letter from your husband, who told me he was on the shore and collecting nudibranchs and I admired his strength and good health. For a long time ago, I am not able to do such a thing myself. And I was glad to be soon able to send him a few papers now under press – they will be sent to you all the same. If I may possibly be of any aid to you about the subject, I should be glad to do so. I fear I can do little, at such a distance". Engel wrote: "Believe, dear Madam, that all my sympathy goes to you, with my personal regrets. Twice I lost my wife and hence I know what it will be for you to bear this great change in your life, but I also know that after the first time of greatest grief a great peace may come with the assured feeling that the deceased is living on in your heart. Nothing can give a better relief than to continue a work which he himself would have enjoyed to finish. Please believe me. Yours sincerely, H. Engel."

Acknowledgements

This paper was supported by the National Science Foundation through a PEET grant (DEB-9978155) "Phylogenetic systematics of dorid nudibranchs," to Terrence M. Gosliner, California Academy of Sciences.

Parasites and diseases of molluscs in Latin America

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The aquaculture of molluscs in Latin America is an increasing economic activity. The culture of *Argopecten purpuratus* in Chile is a consolidated industry. In other countries such as Mexico, the culture of abalone (*Haliotis rufescens*), pectinids (*Argopecten purpuratus*), oysters (*Crassostrea gigas* and *C. virginica*) and mussels (*Mytilus galloprovincialis*) is gaining importance. Oysters and mussels cultured in Baja California are sold in the United States market, while abalone from Mexico and Chile are sold in the Asiatic market. However, parasites and some epibionts may produce negative effects in natural and cultured mollusc populations.

Although the literature on parasites and diseases of molluscs at the international level has increased in the recent years, this kind of study in Latin America is scarce. The available information is spotty, and many times it was produced by Licenciatura or postgraduate theses, or from technical reports which are of limited accessibility. In this presentation, Latin American studies are described that were carried out on parasites, diseases and other epibionts of molluscs which have a negative effect on their development or commercial development.

Among the important parasites are the nematode worm *Echinocephalus pseudouncinatus*, which parasitizes *Argopecten ventricosus* and *Nodipecten subnodosus*; larval cestodes; boring worms from the genus *Polydora*, which produce important economic losses in the culture of *Argopecten purpuratus*, *Crassostrea gigas* and *Haliotis* spp. Moreover, there is information on the copepod *Pseudomyicola spinosus*, living between the mantle and gill branchia and inside the digestive tract of several molluscan species, where tissue damage is produced. Turbellarians such as *Urastoma cyprinae* have been found infecting the mussels *Mytilus galloprovincialis* and *M. californianus*. It is important to increase and diversify the studies on parasites and epibionts of pectinids, in order to protect and increase the culture and natural populations of these clams.

Opisthobranch molluscs from Baja California Sur

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The study of opisthobranchs in the Gulf of California began at the end of the 19th century, with the first works being those done by Bergh (1894). Since then a great number of authors have worked in and published on the opisthobranch fauna of the northern part of the Gulf of California, including but not limited to Lance, Marcus & Marcus, Bertsch, and Gosliner. In contrast the southern part of the Gulf of California (especially the state of Baja California Sur) has been little studied. Therefore, the objective of this study was to determine the species of opisthobranchs that occur in three regions of Baja California Sur: Punta Eugenia-Vizcaino, Bahía La Paz, and Cabo San Lucas. Repeated excursions sampled both the inter- and subtidal regions. During the study, 26 localities were sampled, in which were measured and observed a total of 1247 specimens, grouped into 67 species.

Preliminary results on temporal and spatial variations of the opisthobranch fauna near La Paz, Baja California Sur, Mexico

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Ecological study of opisthobranch mollucs is relatively recent. This is due in part to the small size of the organisms, but especially because of their rarity and/or scarcity, which have often excluded them from quantitative studies of the marine fauna. There is almost no research on this subject in the Gulf of California; the studies of Bertsch at Bahía de los Ángeles are unique.

A one-year study was carried out in the La Paz area. We made monthly samplings at three localities in both the intertidal and subtidal environments. This is the first attempt at a systematic study in the southern region of the Gulf of California. The main goal of the study was to obtain a better representation of the species in the area. Preliminary results include the first six months of sampling. We identified and measured 813 specimens belonging to 62 species. The dominant orders in the intertidal environment were Cephalaspidea (primarily represented by *Navanax inermis*), and Nudibranchia (represented by *Conualevia alba*). In the subtidal region, the dominant orders were Nudibranchia (represented by *Chromodoris norrisi* and *Hypselodoris californiensis*) and Anaspidea (*Dolabella auricularia*). The most common and abundant species was *N. inermis*, followed by *Berthellina ilisima.*

The eastern Pacific Recent species of Corbulidae (Bivalvia)

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There are 18 Recent species of the Corbulidae in the eastern Pacific, of which one has been introduced from the northwestern Pacific. Division of *Corbula* into additional genera is premature without new characters and a formal cladistic analysis. Six subgenera are utilized, with six species remaining in *Corbula, s.l.*

Three new species will be described: *C. (Caryocorbula)* new species 1, *C. (Varocorbula)* new species 2, and *Corbula (s.l.)* new species 3. One neotype and 14 lectotypes will be designated. The distributions and habitats of the species are documented, along with their fossil occurrences and the relationships to other Recent and fossil species.

Morphological analysis of the blue, *Haliotis fulgens*, and yellow, *Haliotis corrugata*, abalone populations in the central peninsula of Baja California (POSTER)

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Abalone species have been described morphologically. However, to our knowledge there are no studies on the morphological variation along the peninsula of Baja California of the blue, *Haliotis fulgens*, and yellow, *Haliotis corrugata*, abalones. These are the most important species in the Mexican abalone fishery. The main goal of this work was to morphologically compare abalones belonging to these species from different localities. Abalone morphological data (shell length, height, number of respiratory pores and weight) from the islands of Natividad, Cedros and San Benito and from Punta Eugenia were analyzed using multiple analysis of variance and a canonical centroid plots. There were significant differences between both species, but the blue abalone localities were clustered together while the yellow abalone data showed significant differences between localities. If the morphological variation in abalone is positively related with its genetic variation, then these results agree with reports indicating that the blue abalone has lower genetic variability while the yellow abalone has higher genetic variability and separated populations around Cedros and San Benito Islands.

Comparative and evolutionary aspects of the biosynthesis of defensive metabolites in the dorid nudibranch genera *Dendrodoris* and *Doriopsilla*

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Comparative studies have suggested possible evolutionary pathways whereby nudibranchs have become able to synthesize *de novo* metabolites that were initially obtained from food. Three nudibranchs, *Dendrodoris krebsii, Doriopsilla albopunctata* and *Doriopsilla areolata* (Doridacea: Cryptobranchia: Porostomata: Dendrodorididae) have been investigated from this point of view. The presence of sesquiterpenes similar to some that are also found in sponges of the genus *Dysidea* has been corroborated. These metabolites are shown experimentally to be synthesized by the nudibranchs, using the same starting compounds but following two different pathways and leading to skeletons with opposite absolute stereochemistry. The data are consistent with the hypothesis that the ability to biosynthesize these metabolites has evolved in the "retrosynthetic mode" with the later stages evolving before the earlier ones. This would be the opposite of what generally has happened and is in fact well documented in sponges and other organisms. A plausible beginning for such a scenario would be the enzymatic modification of toxic metabolites that are derived from food, thereby setting the stage for the evolution of other enzymes that can catalyze earlier steps in biosynthesis.

Patterns of larval development in opisthobranch molluscs from the northeastern Pacific Ocean

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Early life histories, like other biological traits, are shaped by adaptations to environment. To test the hypothesis that regional differences in factors such as planktonic food supply and current speed have selected for predictable patterns in the early life history of shallow-water, benthic marine invertebrates, I have undertaken a global comparison of egg size and larval developmental mode in benthic opisthobranchs. This paper summarizes my findings for the northeastern Pacific Ocean.

Based on a survey of the published literature and my own observations, mode of development is known or inferred for 132 species from the Pacific coast of North America, 116 that range north of Point Conception, California, and 16 whose ranges are restricted to the south. Ninety-one percent of the northern species have planktotrophic development, compared to 56% from the south. Of the 11 northern species with non-feeding development, seven are restricted to bays and estuaries, two are cold water, circumboreal species, and two are from the outer coast. In contrast, all seven of the southern species with non-feeding development are from outer coast habitats, including the Gulf of California.

Bay and estuarine habitats are sparsely distributed on the Pacific coast of North America, and non-feeding development in their inhabitants may have been selected for as an adaptation for retention of offspring near limited adult habitat. In contrast, planktotrophic development appears to have been maintained in the outer coast species (at least those from north of Point Conception) by an environment characterized by slow-moving currents, high primary production, and geographically extensive adult habitat.

The systematic status of MacFarland's genus *Hopkinsia* and its relationship to *Okenia* (Doridina: Goniodorididae)

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The anatomy of ten undescribed species of *Okenia* was examined from several Indo-Pacific localities. The external morphology, coloration, radular tooth structure and arrangement of reproductive organs differ markedly between different species. Of particular note is the arrangement of notal and marginal papillae, the position of the anus and the relationship of the recaptaculum seminis and bursa copulatrix. Various anatomical characters have been used to separate the goniodorid genera *Okenia* Menke, 1830, and *Hopkinsia* MacFarland, 1905. Species of goniodorids with an indistinct mantle margin have recently been placed in *Hopkinsia*, while species with a distinct lateral side of the body have been included in *Okenia*. Other characteristics of the radular teeth and reproductive system are suggestive that these genera are in fact distinct, but that the monophyletic units that are contained within these genera are presently poorly circumscribed. The presence of elongate, recurved inner lateral teeth appears to be a characteristic unique to *Hopkinsia rosacea*, the type species of the genus and an undescribed species from the central and western Pacific. A species-level review is necessary to provide primary data to permit the phylogenetic reconstruction of relationships within these taxa.

Nudibranchs in action

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A video presentation illustrates action clips of the incredibly slow, sluggish movements of nudibranchs and their slime trails. Nudibranchs often seem to just sit there, quite boringly, but are truly engaged in a variety of different activities. Video scenes include feeding by *Roboastra*; copulation and agonistic behavior by *Phidiana hiltoni*; standard morphology shots of nudibranchs, including pulsing and

chemosensory rhinophores protruded into the current; use of radar-like rhinophores in search of sex or food by *Triopha catalinae*; and, withdrawing of the rhinophores into the body and wiggling/vibrating the gills in *Risbecia tryoni*.

Fecundidad de abulon azul (*Haliotis fulgens*) en Bahia Tortugas, Baja California Sur, en El Niño de 1997

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En 1997 ocurrió el evento de El Niño más intenso del siglo XX y durante ese año las poblaciones bentónicas características de la costa rocosa de Baja California fueron severamente afectadas. Entre éstas, los mantos de sargazo gigante (*Macrocystis pyrifera*) y las poblaciones de abulón (*Haliotis* sp.) mostraron un descenso inmediato en las densidades de sus elementos adultos y juveniles. Aprovechando la presencia de este evento se hizo una estimación de la fecundidad de abulon azul *Haliotis fulgens* en la zona de Bahía Tortugas, Baja California Sur.

Se analizó una muestra de 35 especímenes adultos maduros cuya talla fluctúa entre 115 y 199 mm de longitud de concha. Se estimó el índice gonadica para obtener la fecundidad absoluta. Los valores encontrados fluctuaron entre 0.99 x 106 ovocitos para especímenes de 115 mm y 22.3 x 10.6 para abulones de 198 mm. La relación entre fecundidad y longitud fué potencial ($r^2 = 0.5267$). La ecuación obtenida fué $F = 4 \times 10^{-9}$ L4.07. El diámetro promedio de los ovocitos fué de 219 mm - 1.9 lo que coincide con ovocitos listos para su expulsión.

Modes of formation of gastropod operculum concentrations

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Operculum-rich bioclastic accumulations, although rare, are particularly intriguing taphonomic puzzles. They provide especially valuable insight into taphonomic processes in which there is a strong biological overprint on the physical and sedimentological signatures that normally dominate shell beds.

Gastropods with calcified opercula have bipartite skeletons in which the two elements differ markedly in size and shape. The two elements may differ as well in density and microstructure. As a consequence, shells and opercula have different taphonomic properties and the strong potential for different modes of post-mortem transport, accumulation, and preservation. Because the operculum is attached to the gastropod foot, it separates from the shell either (a) at death, if the animal is consumed by a predator, or (b) shortly after death with disintegration of the soft parts.

In the fossil record, calcareous opercula have attracted attention primarily in the rare instances in which an operculum is preserved in place within the shell aperture. There are very few reports of bioclastic deposits containing large numbers of opercula and even fewer reports documenting separate taphonomic concentrations of shells and opercula at contemporaneous sites.

Biostratinomic reconstructions of three turbinid gastropod operculum accumulations illustrate different causative mechanisms and the interplay of sedimentological, taphonomic, and biological processes. These examples include a dense lag concentration of opercula formed predominantly by winnowing in a modern eolian deposit, a Holocene operculum concentration with strong evidence of ecological control by a predator, and a series of Neogene operculum concentrations dominated by storm events and hydrodynamic control.

Sea hare defensive secretions function differently against fish, crustacean and cnidarian predators

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Though sea hares face few threats from specialist predators, they do occasionally fall prey to generalists such as fish, crustaceans, and sea anemones. To determine how secretions from sea hare ink and opaline glands may affect predators we conducted feeding assays with sympatric species reported to feed on sea hares in the field.

In field assays with live *Aplysia parvula* and *Stylocheilus longicauda*, reef fish were not deterred by ink/opaline secretions. We offered fish individual sea hares with either full or depleted glands. All of the *S. longicauda* were eaten regardless of gland fullness while most of the *A. parvula* were rejected regardless of gland fullness. Many fish, however, appeared to show a startle response after ink release that significantly delayed further attacks.

We tested spiny and slipper lobsters and portunid crabs with live sea hares and pure secretions of *Aplysia californica, S. longicauda,* and *Dolabella auricularia.* Live sea hares were readily attacked and eaten but were often dropped if ink/opaline was released. Both isolated secretions proved highly stimulatory to feeding and may function as a feeding distractant that allows the sea hare to escape.

Aplysia ink causes a “vomiting” response and tentacle shriveling in sea anemones. Ink from several sea hares is known to contain an antibacterial/cytotoxic protein that we hypothesize may be involved in this response. We isolated such a protein from *A. californica.* Pilot studies show that ink samples heated to 90° F (to denature proteins) no longer cause such negative effects in sea anemones.

A preliminary phylogeny of the genus *Cadlina* (Mollusca: Nudibranchia: Chromodorididae)

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Chromodorid nudibranchs are usually brightly colored animals, mostly found on tropical coral reefs. In contrast, members of the most basal group in the family Chromodorididae, the genus *Cadlina*, are either white or drably colored and are primarily found in cool temperate waters with a few species known from the adjacent subtropics. *Cadlina* species also differ from many other chromodorids in the texture of the mantle, the shape of the radular teeth and the arrangement of the reproductive organs. Although *Cadlina* and all of the other chromodorids are united by the presence of defensive mantle glands, some authors have suggested that *Cadlina* species are different enough to be placed in their own family. There are at least 24 species in the genus *Cadlina*, with representatives found in the southern ocean, the eastern Pacific, the Mediterranean, the Atlantic, New Zealand, Australia, Japan and South Africa. The cadlinid fauna in many of these different regions has been reviewed, but a hypothesis of relationship of all of the species of *Cadlina* has never been presented. An understanding of how species of *Cadlina* are related will help us understand the biogeographic patterns we see today. It will also give us insight into the evolution of the Chromodorididae.

Marsh conditions associated with high population densities of unusual snails appearing in certain restored marshes of San Francisco Bay Estuary

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Introduction

Most marsh restorations have prepared for water flow and some plants, but rarely for native aquatic animals. Marshes on various shores are known to provide productive nursery areas for valuable fisheries and shellfisheries, and possibly other native animals. In this multi-disciplinary project, I sought factors that account for restorations that attract many aquatic animals. This non-destructive sampling of fishes and macroinvertebrates, while comparatively monitoring their possibly limiting physical factors, was intensive for >2.5 yrs at an array of marshes in the northern San Francisco Bay Region (Fig. 1). Over four of these marshes were restored recently to increased tidal action, and three historic marshes nearby were used as reference sites. More than three other marshes were added for supplemental sampling and more replicated comparisons. Hypothetically, the age of a marsh and other attributes are related to aquatic animal abundances, especially for native animals.

Methods

Kitting (2001) presented summaries of year-round biological and physical factors at each marsh, located at ~10-km intervals in the upper San Francisco Bay Estuary. Major sites in this study were centered at 38° 2.5' N, 122° 4.4' W. Underwater in the marshes, physical factors were sampled almost continuously with YSI 600XLM data loggers (Yellow Springs Instruments, Ohio) having temperature, conductivity, salinity, and oxygen electrodes. The most versatile, replicated biological methods were virtually continuous, flexible plastic mesh "minnow-trap" refugia with a ~4 cm funnel at both ends, 0.5 m^2 area inside and out, totaling 1 m^2 (imported by Nichols Net, Illinois), and with 0.1 m^2 of additional mesh inside. The additional mesh provided additional refugia for animals inside, minimizing predation by

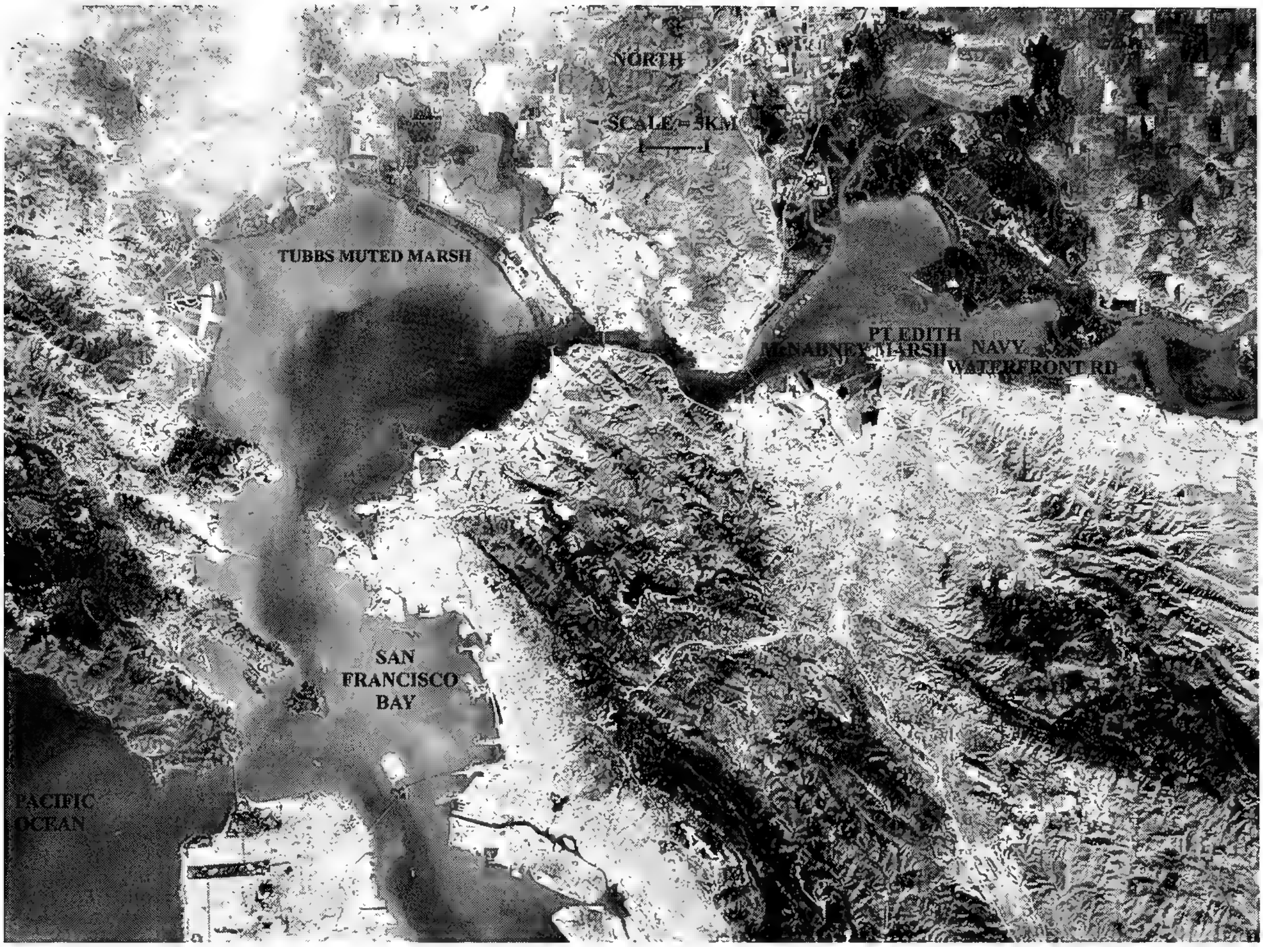

Figure 1. Aerial photograph of northern San Francisco Bay Estuary, labeling major study marshes restored to tidal action. North is up. Sacramento and San Joaquin River Deltas are to the right.

animals within the "trap". Mesh openings were 2 - 4 mm wide. At each site, two to five modified traps were left on the bottom for at least two weeks between counting the macroinvertebrates and fishes contained within them. Animals stocked into these refugia were seen to come and go during such periods, implying a roughly steady state of most populations after weeks. This approach was analogous to smaller "basket traps" described by Levings (1976). Upon ~monthly sampling at each site, virtually all animals in refugia were recorded and released immediately back into the marsh.

Results

One set of marshes (Tubbs Island) at the northernmost edge of San Francisco Bay displayed salinities of 7 to ~25 ppt, with common bay molluscs distinct from the other sites. Eastward (upstream ~20 km of Tubbs Island), at other study marshes (in Suisun Bay), ranges of physical factors were comparable among the historic reference marshes and most of the restored marshes. These marshes spanned salinities of 2 to ~10 ppt (4 to ~30% seawater), with salinity at each site fluctuating ~50 % throughout the year. Channel depths were 1~2 m at high tide, with 0.5 to ~2m tidal amplitude.

Refugia trap and other monthly sampling failed to detect much fish or invertebrate usage of the historic reference marshes, with total macroinvertebrates (mainly gammarid amphipods) averaging <<5 per m^2 refugium, with virtually no snails or fishes. Less frequent sampling of several other such marshes confirmed low abundances of aquatic animals there as well. These reference marshes appeared quite pristine, but had virtually no common macroinvertebrates or fishes. Furthermore, about half of our restored marshes had few aquatic invertebrates and fishes.

In contrast, two of our systematically sampled marshes restored to moderate tidal action (Tubbs Muted Marsh and Waterfront Rd.) and another (Shell/McNabney Marsh) that had been restored to minor tidal action, yielded relatively high population densities of diverse invertebrates and fishes. After gammarid amphipods, insects, and isopods, the most common macroinvertebrate taxa were both pulmonate and prosobranch gastropod snails, generally less than 1 cm in shell length. The only feature these rich sites shared was the unusual presence of marsh "ponds" (permanently inundated marsh) on the intertidal channels of the marshes.

Subjectively and statistically, despite seasonal fluctuations, marshes without ponds had fewer snails (averaged monthly and year round) than did marshes with connected ponds (Mann-Whitney $U' = 921$, corrected for ties, $P = 0.04$). Overall, most aquatic macroinvertebrates sampled (>64% of mean abundances in refugia traps among sites) were apparently native gammarids, insects, and snails.

The most common snail species found at low salinities was *Physella heterostropha*, which occurred at shell lengths of <1 cm (Kitting 2001). This species is reported over a wide geographic range. Here, it was concentrated near the water's surface, averaging1.5 – 2.5 snails per 1 m^2 refugium. Its highest population densities were recorded among *Lemna* duckweed nearby, with over 120 macroscopic snails

per 0.05 m^2 sample (= 2400 per m^2). Among widespread, emergent *Distichlis* saltgrass, *P. heterostropha* reached 40 per 0.05 m^2 sample (= 800 per m^2).

Another snail species was found at slightly higher salinities and appeared suddenly, reaching population densities in excess of 20 per m^2 on submerged minnow traps coated with algal growth and on shaded algae. This newly colonized species is an unidentified hydrobiid (Prosobranchia) up to 4.5 mm long (Fig. 2). It appears to be closely related to the only snail from California on the endangered species list, the "California brackish water snail", *Tryonia imitator*. Taylor (1966) provides a taxonomic summary of this species and several relatives.

After no record of snails for >two years in these recently restored marshes (Kitting, 2001), this species became concentrated on shaded surfaces, hidden among algal growth. Other sites within a 5-km radius (including more than five restored and historical marshes) had similar conditions but essentially no snails or other macroinvertebrates unless ponds and algae were present (in three restored marshes). In the laboratory this snail devoured filamentous algae, including cyanobacteria and diatom chains.

Water conditions corresponded to the recruitment and then decline of the hydrobiid snail (Fig. 3). Conditions fluctuated somewhat with tidal state and daylight, and largely with season. During colonization, tidal amplitudes = ~1 m, salinities = 2.4 -11.1 ppt (mean = 6.4ppt, or ~20% seawater), temperatures = 5.0 -11.3 C (mean = 8.7 C), and oxygen near saturation (well mixed). Other sites within a 5 km radius had similar conditions, but essentially no snails or other macroinvertebrates (in more than five restored and historical marshes) unless ponds and algae were present (in three restored marshes). All sites had silt bottoms <2 m deep, emergent marsh vegetation, and moderately low water clarity (~30 cm secchi depth). The water conditions several months later, during the snail's initial decline, exhibited rapid changes in conditions, with the salinity averaging 7.1 ppt (ranging from 4.3 -11.9 ppt) the temperature averaging 21 C (ranging from 7.2 - 29.1 C). The population later recovered and persisted through July, 2001.

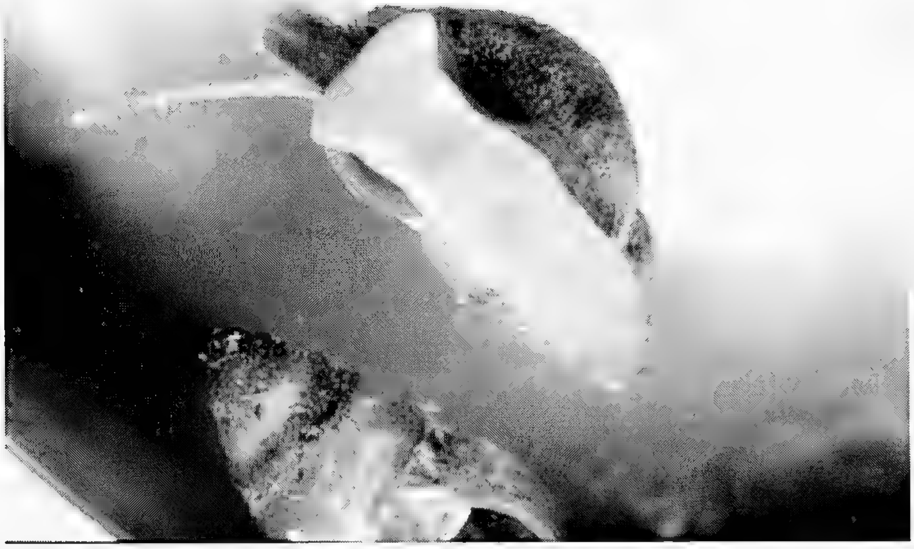

Figure 2. Ventral view of unidentified hydrobiid snails (4 mm in length). Brackish Waterfront Road Marsh, June, 2001.

Discussion

The results of this study clearly reject the hypothesis that historic marshes possess higher population densities of aquatic animals than recent restorations. Even at higher salinities (Kitting 2001), diversity of marsh animals appears to be positively correlated with the presence of marsh ponds. Our historical marshes nearby do not possess such ponds and yielded few aquatic animals. This finding is consistent with West and Zedler (2000), whose sites near San Diego that I observed in June 2001 had rich marsh ponds like those of the present study. Sommer et al. (2001) showed the importance of larger-scale, seasonal ponding to foster native fishes and their foods upstream in the Sacramento-San Joaquin River Delta.

James McLean and others are assisting with identifying and classifying this newly discovered hydrobiid snail. It does not appear to be described from elsewhere in the world, except possibly as a fossil from the

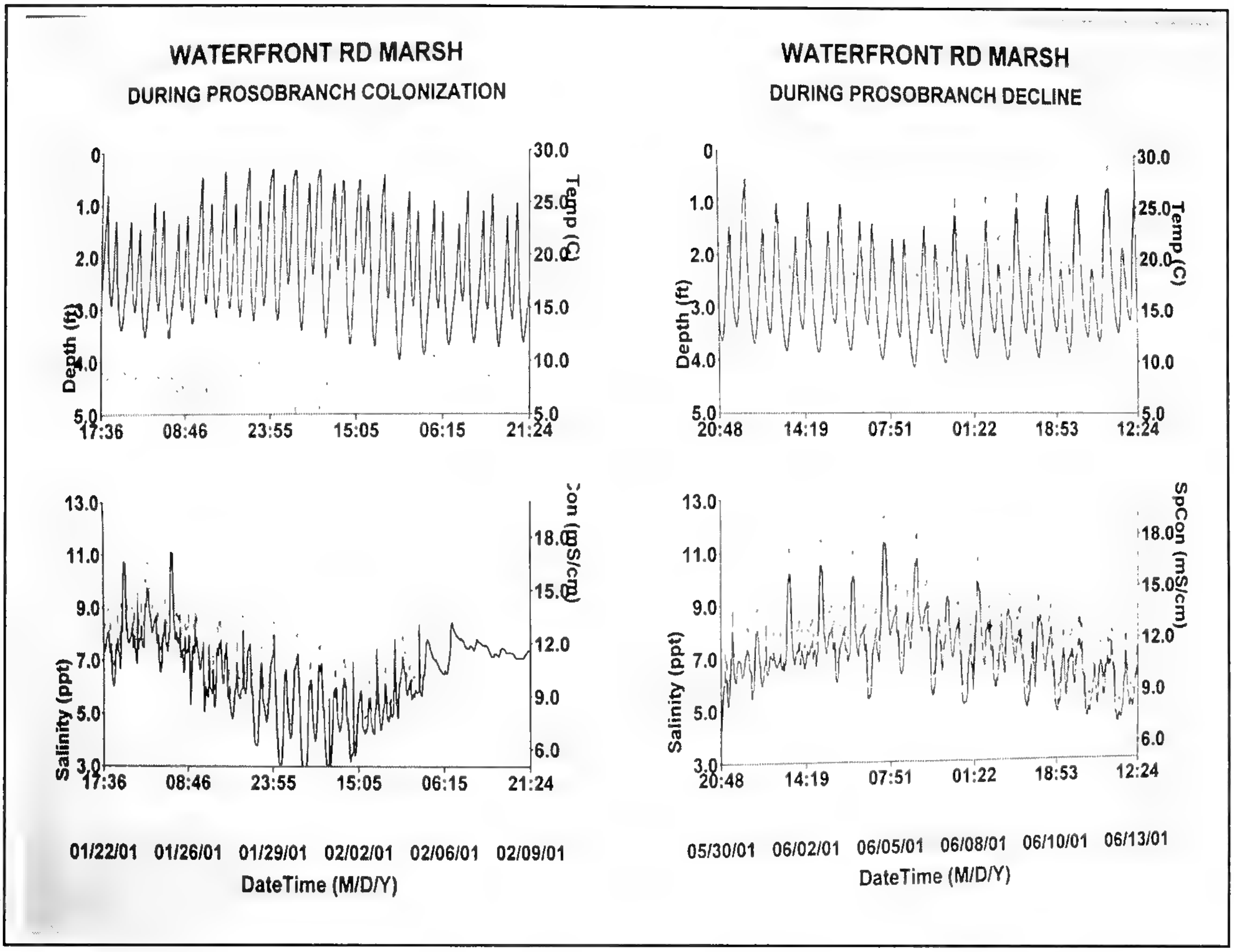

Figure 3. Virtually continuous physical factors (every 12 minutes) over a one-month period at Waterfront Rd. Marsh site during colonization by the hydrobiid snail, then several months later during an initial decline. Thinned traces correspond to the right-hand axes.

ancient San Joaquin River Basin in the San Joaquin Valley of California (McLean, pers. comm.). Almost all other hydrobiids are freshwater rather than brackish. Unlike many curious appearances of unknown species, this region seems somewhat less likely than other areas to be subject to species introductions. The entire region is protected by the US military as a buffer for a weapons depot >5 km away on open water.

Since colonization did not occur for >2 years, if one is patient these particular conditions with ponds may

prove to favor this unusual snail and other invertebrates, mainly natives. Furthermore, these invertebrates all were abundant even when and where fishes and predatory crustaceans were most common (Kitting 2001). Fluctuating, low salinities and permanent but tidally circulated ponds may be crucial for dense aquatic animal populations to colonize and persist in such marshes, restored or historic.

Microhabitats of this unusual, but recently common, snail were among dense algae, especially in dim light. These results are analogous to previous findings on other shores, where small algae attracted small aquatic animals (van Montfrans et al., 1982), especially at night (Kitting, 1984). Morse et al. (1984) demonstrated an apparently widespread mechanism of molluscan (and other) recruitment to various algae, inducing metamorphosis from larvae. However, such marsh sites are particularly difficult to sample non-destructively for animals among algae. Further progress with restoration and monitoring of these largely lost habitats (Onuf et al. 1978) may produce additional animal and algae populations that otherwise may be lost.

Acknowledgements

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Pulmonate Mollusca persisting in California Delta marshes with high tidal and physical/chemical extremes

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Several marshes located along the outer San Joaquin /Sacramento River Delta have been restored to higher tidal action following the removal of levies and tide gates and are presently being monitored. Prior to their removal, these levies and tide gates had largely isolated the marshes from San Francisco Bay and the outer River Delta. As a result of the increased tidal flow, salinities and other environmental parameters have become more variable, with tidal cycles up to 2 m in amplitude. Among restored and reference sites and at the nearby saline and freshwater reference sites, estuarine winter salinities ranged from 0.5 to ~ 10 ppt (2 to ~30% seawater) and estuarine summer salinities ranged from 1.0 to ~20 ppt (3 to ~60% seawater). Temperatures in these shallow waters were moderate and ranged from 10 to ~25 C near the bay and 5 to ~30 C further (~20 km) from the bay. Particle loads in the water were almost always high, with various sites averaging 10 to ~ 50 cm water clarity (as secchi depth).

A variety of non-destructive sampling methods have been used to monitor these marshes for 1.5 yr. Epibenthic sampling with replicate thrown cages yielded live bivalves and pulmonate gastropods, with almost no other live molluscs at estuarine sites. The most common mollusc at estuarine sites has been a freshwater pulmonate snail, *Physella heterostropha*, which was abundant (year-round) only at the two sites fed by an adjacent reclaimed water marsh. Other invertebrates and fishes also were most abundant there, where salinities were low, ranging 0.7 to ~2.2 ppt (up to brackish) but particle loads were highest (down to 10 cm water clarity), and temperature ranges were extreme. The other low-salinity estuarine site had more variable (usually higher) salinity, low pulmonate population densities, but high abundances of *Macoma balthica* bivalves (commonly up to ~3 cm long) near the sediment surface. Curiously, pulmonate slugs were detected in even saltier marshes (2 to ~5 ppt) with high temperature extremes. The highest salinity among these estuarine sites, in north San Pablo Bay, had the second highest molluscan population abundances (Table 1).

Marsh Restorations: (in order of increased tidal flow)	Tidal Range (ft)	Temp. Range	Approx. Clarity (cm)	Salinity (ppt)	Zoo-plankton	Major Epi-benthos	Major Fishes	Major Mollusks	Con-nected Ponds?	Major Conditions	Site Identification
Outer Bay Reference (not modified)	8	medium	20~90	10~25	low	medium	medium	*Ilyanassa & Macoma*	yes	shoreline marshes	central bay
Estuarine Reference (not modified)	7	high	20~60	4~10	low	medium	rare	none	no	2-m deep intertidal channel	state lands
Estuarine Reference (not modified)	7	medium	20~50	3~6	low	low	rare	none	no	perm. 2-m deep channel	Edith West
Reference Creek Mouth (~not modified)	7	medium	20~35	2~6	low	low	medium	*Macoma*	no	perm. 2-m deep channel	Pacheco
Fresh Tidal Reference Marsh	5	high	20~90	0~0.3	low	medium	medium	*Corbicula & Physella*	yes	delta tule marshes	Big Break
Estuarine Restorations:											
1991 Restoration (old) (to increased tidal flow)	6	high	15~25	2~4	low	low	rare	none	no	2-m deep intertidal channel	U. S. Navy
1990 Construction (periodic tidal flow)	0.1-0.4	medium	10~15	0.7~2	high	medium	~common	*Physella*	yes	oxygen risk in ponds & channels	out McNabney/ Shell Marsh
1990 Construction (minor tidal flow)	0.2	medium	10~15	1~2	high	high	~common	*Physella*	yes	ponds & channels	up McNabney/ Shell Marsh
1998 Restoration (recent) (to increased tidal flow)	6	high	15~25	2~5	low	low	rare	*Arion*	no	2-m deep intertidal channel	Edith
pre-1999 Increase (pre-restoration)	4	medium	10~25	10~20	medium	medium	~common	none	yes	perm. ponds & channels	Tubbs Muted Marsh
1999 Increase (partially restored; 1.3 yr)	5	medium	10~25	5~20	medium	medium	~common	*Ilyanassa*	yes	perm. ponds & channels	Tubbs Muted Marsh

Table 1. Comparisons of north San Francisco estuary marshes (eight estuarine marshes plus seaward and landward tidal marshes), restored to different degrees of tidal action through time.

These distributions of mollusks, abundant at only three of the eight estuarine marshes, reflected distributions of other invertebrates and fishes (Table 1). The pattern did not reflect merely salinity gradients, but rather the occurrence of shallow ponds along tidal creeks. Both estuarine reference marshes and the three other restored sites, each without ponds connected by tidal creeks, yielded very few molluscs, very few other invertebrates, and few fishes (Table 1). Living on nearby sediments near each site, bivalves, including the Asian clam *Potamocorbula amurensis*, recently had been common.

Thus, the above mentioned molluscs persist among extreme conditions in these brackish tidal marshes with ponds on tidal creeks, while prosobranch gastropods and other molluscs are virtually absent at nearby marshes without ponds. However, the prosobranch *Ilyanassa obsoleta* and other molluscs are abundant only seaward in San Francisco Bay, and numerous *Corbicula fluminea* (bivalves) are only recorded up river, in the nearby freshwater Delta (Table 1).

Acknowledgements

Gratitude is extended to C. L Hamer and others for assistance, A. Wellington and R. Dillon for *Physella* taxonomic information, and CALFED/US Fish and Wildlife Service for partial funding.

High population densities of patchy snails and associated habitat conditions in restored marshes of San Francisco Bay Estuary

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Marshes are being restored to higher tidal action in northern San Francisco Bay Estuary. For over two years, we have monitored more than ten restored and reference marshes, which span salinities of 2 - 15 ppt (3 - 40% seawater), in northern San Pablo and southern Suisun Bays. Our approximately monthly marsh sampling with non-destructive replicated methods showed snails and other aquatic invertebrates and fishes to be rare in our two historic reference marshes. However, various taxa were much more common periodically in several of our marshes experimentally restored to increased tidal action. Historic

and restored marshes without ponds or channels yielded very low animal population densities. Mobile aquatic taxa tended to be similar among other sites, but each gastropod species appeared generally in patches, each near population densities of about 10 - 50 snails/m^2. Snail and egg distributions often corresponded to solid surfaces in these muddy marshes, such as on submerged vegetation or on our sampling devices underwater.

Paired YSI 600XLM data loggers continuously monitored water chemistry over >24 hour periods where each snail species appeared. Water conditions fluctuated somewhat with the tide and daylight, with conditions similar between each upper (shoreward) and lower (seaward) marsh region. Those particular marsh conditions may favor each of these less mobile aquatic animals. These snails were abundant even when and where fishes and predatory crustacea were most common.

Developmental dimorphism in the specialist herbivore, *Alderia modesta*: Consequences for dispersal and larval settlement behavior

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The mollusc *Alderia modesta* produces both long-lived feeding larvae and short-lived non-feeding larvae, allowing the intra-specific comparison of alternative larval morphs. Development mode varied seasonally in the field population; adults produced only lecithotrophic larvae during summer months, but roughly half the population shifted to planktotrophy in the winter. Lecithotrophic individuals exhibited a bet-hedging dispersal strategy, producing 0-90% larvae that spontaneously metamorphosed within a day of hatching, while sibling larvae delayed metamorphosis indefinitely until encountering the obligate adult host alga *Vaucheria longicaulis*. Metamorphosis was induced by dissolved, as well as surface-associated, carbohydrates produced specifically by *V. longicaulis*. The water-soluble cue accumulated within algal patches in the field, and was naturally released into the surrounding sea water on each flood tide. Both lecithotrophic and competent plankotrophic larvae immediately responded to waterborne cues from the algae by increasing their turning rate, changing swimming speed, and sampling the bottom.

Larvae were behaviorally entrained where the dissolved cue was perceived, and prolonged exposure increased the percentage of larvae that metamorphosed. Lecithotrophic larvae had greater swimming speeds and vertical transport rates, but competent planktotrophic larvae responded more strongly to chemical settlement cues and completed metamorphosis at a faster rate. Larval behavior may thus function as trade-offs against the costs of different life-history strategies in marine invertebrates.

A survey of Panamic Sacoglossa (Opisthobranchia: Gastropoda)

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Some 25 species of sacoglossan Opisthobranchiata from inshore eastern Pacific warm waters (Panamic Faunal Province) are currently identifiable. Of these, at least ten are undescribed and have aided in increasing our understanding of inter- and intra-Province sacoglossan relationships. New observational and photographic examples of direct development, extrazygotic yolk strings, tight aggregate feeding, endemism within a single bay, and old and new recruit records from other seas are presented.

Revision of Liotiinae (Vetigastropoda: Turbinidae) of the world

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Liotiinae are small-shelled marine gastropods of nearly worldwide distribution, characterized by their nacreous interiors, fine lamellar sculpture and thickened terminal lips. In addition, an important diagnostic character is the circular aperture, which accommodates a multispiral operculum with a long growing edge and detachable calcareous beads. A monograph of Recent and fossil taxa is in preparation, in which three subgroups have now been recognized:

Dichostasiinae, with 8 extinct genera and 11 known species, occurring in the Permian, Triassic, Jurassic, Cretaceous, and Eocene, of which one Eocene genus is undescribed. These are the pre-liotiines, lacking stellae of clumped lamellae connecting the early whorls, but having the circular aperture and thickened lip that is indicative of the entire group.

Liotiinae, *s.s.*, with 41 genera (of which 28 are new) and 164 living species (of which 111 are new), known first from the late Cretaceous (based on a species described by Sohl, 1998). Twenty-three fossil species are known. Stellae of clumped lamellae connect the early whorls in apical view and the umbilical wall is spinose; the shell is white and strong axial sculpture is dominant. Generic characters are based on structure of the final lip, and other features of mature sculpture, which may be highly intricate. Some genera have a spur that fortifies the final lip, an emergent ridge derived from the coalescence of umbilical spines.

Areneinae, with 18 genera (of which 14 are new) and 91 living species (of which 53 are new), known first from the late Cretaceous (based on two species described by Sohl, 1998). Twenty-four fossil species are known. Apical stellae are reduced, but the umbilical wall is spinose. The shell has a color pattern; spiral sculpture is dominant. Generic characters are based on differences in early teleoconch sculpture as well as differences in the mature lip.

Turbiniform to discoidal genera are known in each subgroup. Radulae are generally uniform in living groups, and hardly differ from those of other primitive turbinids.

Gymnodorid nudibranchs from the eastern Pacific: a preliminary taxonomic revision of the genera *Tambja, Roboastra*, and *Nembrotha* (POSTER)

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The Gymnodorididae are nonsuctorian phanerobranch dorids that are overdue for taxonomic revision by modern phylogenetic methods. We have initially focused on the eastern Pacific species because of the availability of fresh material for DNA work. For the morphological analysis we have examined both the radula and the reproductive system from several species. As a molecular marker, we have sequenced a 700 bp fragment from the mitochondrial cytochrome oxidase subunit 1 (CO1) gene from four *Tambja*, one *Roboastra* and two *Nembrotha* species (the latter from the Indo-Pacific). A preliminary phylogenetic analysis of the molecular data set indicates that CO1 will help elucidate relationships within this dorid family. For instance, two new *Tambja* spp. from Costa Rica were identified as *T. eliora* and *T. abdere* based on the genetic data, even though they are very different in their external morphology.

Seasonal occurrence patterns of opisthobranchs in the Northeastern Pacific

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Since 1971, I have listed opisthobranch sightings in my diving logs, including spawning records. I have also collected similar data during numerous intertidal trips. To help establish the optimal time to search for particular species, I have compiled all my logs into a database. The results, summarized here, give a portrait of seasonal occurrence and spawning patterns in the waters of southern British Columbia.

Beyond the tub: An underwater slide presentation of various nudibranch behaviors noted in a May 2001 Philippines field trip

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Selected slides will be shown exhibiting certain nudibranch behaviors in conjunction with new and unusual specimens observed during the trip to the Batangas and Palawan regions of the Philippines in May of this year. Special emphasis is placed on the relationship between the animal and the substratum, and the audience is challenged to validate this relationship in a meaningful way.

Some land molluscs from Santiago Papasquiaro, Durango, Mexico

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Terrestrial molluscs from 11 sites around Santiago Papasquiaro, Durango, were collected between June 1994 to August 1996. Santiago Papasquiaro lies in central Durango (west-central Mexico); vegetation in the area goes from Chihuahuan desert in the lowlands to pine-oak forest in the higher zones. Samples were taken by looking at suitable snail habitats, such as: under logs, leaf litter, crevices in rock or bark. The molluscs were then picked by hand or samples of leaf litter or humus were taken. These samples were taken in zip-loc bags to the laboratory for processing.

A total of 26 species were identified. Three records appear to be new for Mexico: *Punctum randolphi* (Dall, 1895), *Gastrocopta pilsbryana amissidens* Pilsbry, 1934, and *Columella alticola* (Ingersoll, 1895). Interestingly, six species (*P. randolphi, G. pilsbryana amissidens, C. alticola, Cionella lubrica morseana* Doherty, 1878, *G. oligobasodon* (Pilsbry & Ferriss, 1910), and *G. dalliana media* Pilsbry) increased their range from New Mexico and/or Arizona or states further north, or from Mexico proper, to this area in western central Mexico.

Effects of "El Niño" 1997-1998 on the benthic malacofauna on rocky substrates in the islands of Callao, Peru

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The object of this investigation is to determine the effect of temperature variation during "El Niño 1997-98" on the abundance and biomass of the principal species of molluscs in the rocky subtidal zone. Two study sites were chosen, the first on Isla Palomino (12° 12' 35" S; 77° 23' 10" W) and the second on Isla San Lorenzo (12° 08' 55" S; 77° 23' 30" W). The methodology used was simple random sampling, establishing a station in each study area. A total of 12 samples were done during a period of 18 months. At each station 6 replicate samples were collected by a scientific diver, using as a unit of sampling a designated area of 0.25 m^2. In the laboratory the specimens were separated and identified. Finally, they were numbered, weighed, and grouped to lowest taxon.

Nine species of molluscs were analyzed. In the case of *Semimytilus algosus*, the decrease is total beginning with the month of January 1998. For *Thais haemastoma* there is a negative tendency in abundance and biomass with regards to temperature increase. For *Thais chocolata*, there is a light fall during the first temperature peak; during the second temperature peak, the abundance diminishes constantly in the area of Palomino. *Crassilabrum crassilabrum* and *Xantochorus buxea* present two peaks, which are observed after the cold months. *Nassarius gayi* and *Mitrella buccinoides* also show a similar tendency. The abundances of *Tegula euryomphalus* and *Crepipatella dilatata* tend to decrease gradually. In all the cases, it was observed that after the second temperature peak, in January and February 1998, the abundance and biomass dropped notably; some species were not able to survive the conditions and disappeared competely.

Population genetics of the blue, *Haliotis fulgens*, and yellow, *Haliotis corrugata*, abalones at Cedros and San Benito Islands, Baja California, Mexico (POSTER)

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The blue, *Haliotis fulgens,* and yellow, *Haliotis corrugata*, abalones are the most commercially important species caught in central Baja California. Around Cedros and San Benito Islands, abalones are mainly distributed in three zones: the north (Punta Norte), south (San Agustín) of Cedro Island, and around the small islands of San Benito. The main goal of this work was to characterize genetically populations of the blue and yellow abalones in these three zones. Allozyme electrophoresis at eight loci was carried out with 13 samples overall from two years in the three localities. The yellow abalone had higher number of alleles per locus, mean unbiased and observed heterozygosities and polymorphism than the blue abalone. Agreement with the Hardy-Weinberg equilibrium was found in most of the cases, but in both species their respective F_{ST} values showed population differentiation between localities. These results do not agree with other genetic reports on *H. fulgens* populations along the peninsula of Baja California, and we suggest that fishing pressure, genetic drift, or the lack of migration among fishing areas could account for the population structure found in the islands. These results may help in fishery management of the species.

A highly diverse invertebrate fauna from the Upper Pleistocene Palos Verdes Sand, Costa Mesa, Orange County, California

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Abundant marine fossils from the first terrace sands of the Palos Verdes Sand were exposed during the extension of State Route 55 in 1989. Although collecting was limited by construction activities, a large mixed death assemblage was recovered seven meters below the surface and has been placed in the collection of the San Diego Natural History Museum as Locality 4447. This fauna represents the most inland occurrence of Palos Verdes Sand fossils in Costa Mesa. Specimens recovered from this site include the remains of molluscs, barnacles, crabs, a coral, an echinoderm, and marine vertebrates.

The invertebrate fauna consists mostly of subtropical species encountered along the coast of southern California today that inhabit sandy bottoms from low intertidal to subtidal depths (e.g., *Olivella biplicata* and *Sisula dolabriformis*). A few of the species are tropical, such as *Muricanthus nigritus, Chione gnidia*, and *Thais biserialis*. A relatively large number of species that live on a hard substrate (e.g., *Hinnites giganteus* and *Megathura crenulata*) are uncommon and tend to be worn, suggesting post-mortem transport. This hard substrate was possibly an exposure of the Capistrano Formation and was bored by clams (e.g., *Platyodon cancellatus* and *Zirfaea pilsbryi*). Exposed sandy shore species (e.g., *Tivela stultorum* and *Amiantis callosa*) are common and well preserved, suggesting the site was near a surf zone on an exposed shore. Several estuarine species, including *Melampus olivaceus* and *Cerithidea californica* are present but not common, and were probably transported from a nearby bay.

Clam-ring time-series: A new method for high-resolution environmental reconstruction

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Introduction

Reconstruction and modeling of the Holocene environmental and climate history is based on proxy data. Tree-ring width and tree-ring density chronologies have been used extensively for the reconstruction of the year-to-year environmental and climate variability in boreal, terrestrial latitudes (Fritts, 1976; Schweingruber et al., 1983). Other proxi data were obtained, for instance, from ice cores, lake sediments and coral-ring chronologies. Our models, however, are incomplete, because no high-resolution datasets exist for the marine, extra-tropical realm. Mollusks provide the unique opportunity to fill this gap for the following reasons: (1) high-resolution archiving – mollusks grow by periodic accretion of shelly material producing distinct annual, fortnightly and even daily growth increments and growth lines; (2) the growth rate of mollusks is controlled by environmental parameters – favorable environmental conditions can increase growth rates resulting in wider growth increments and can also control anatomical microstructures and the geochemical properties of the growth increments; and (3) broad biogeographic distribution – mollusks inhabit almost every environment; living on the land, in lakes, in the deep sea, and in tropical, boreal and polar regions.

Although some bivalve mollusks live for up to 250 years, most species are shorter-lived and the time period of environmental reconstruction using these species would be short as well. How can we use short-lived bivalves for continuous long-term environmental and climate prediction? What kind of environmental information can be reconstructed from intertidal bivalves in the northern Gulf of California?

Material and Methods I

The study area is located in Colorado River Delta in the northern Gulf of California. Summer temperatures exceed 35°C; winter temperatures can drop below 5°C. The tidal regime is semidiurnal with a mean tidal range of about 5m. Average salinity of open gulf water is approx. 38‰ +/- 2‰ in this area. We collected bivalve mollusks in the mid-intertidal zone: *Chione cortezi*, *Chione fluctifraga* and *Chione californiensis*. The average ontogenetic age of specimens of these species is between 6 and 10 years (Schöne et al., 2001).

Growth controls:

Annual growth lines are clearly visible on the external shell surface. Their formation results from growth retardation during the cold season of the year. In radial cross-sections, intra-annual growth lines are developed. These were shown (Schöne et al., 2001) by experiments to form fortnightly and daily. Previous studies also demonstrated that environmental parameters control growth rates. Growth in *Chione* spp. is mainly controlled by variation in temperature and salinity. Growth starts when temperatures reach about 17°C in spring. Maximum shell production occurs in early summer at 25°C. Growth ceases as temperatures continue to rise above 29°C. After hot summer growth resumes and reaches another growth rate peak at 25°C in fall. As it cools down in late fall and winter, growth rate decreases and finally halts. Growth is clearly reduced during major river water discharge events in spring (lowered salinity). Knowing how intra-annual growth rates of a species in a given habitat are controlled by environmental parameters is the precondition for interpreting the variability of annual growth rates. We measured annual growth increment widths of 67 live-collected specimens and 7 shells found dead and gaping.

Relative growth rates:

Annual increment width chronologies exhibit characteristic growth trends. As the mollusk shell grows, the shell production rate decreases, resulting in smaller annual increments. A second observation is that the variance of growth rates decreases with maturity. In order to compare growth rates of different specimens, age-related growth trends must be removed from the chronologies by mathematical modeling.

The general growth trend can be approximated with an exponential model as follows:

$$L(p)_t = L(p)_\infty (1-\exp^{-kt}),$$

where $L(p)_t$ is the predicted shell length at time t, $L(p)_\infty$ the predicted, asymptotic shell length and k a growth constant.

Further calculations require determination of the first derivative of the observed (o) and predicted (p) growth data, i.e., the change in the relative growth rate from one year to the next. This is accomplished by calculating the slopes (m) between the shell lengths of successive years for both the observed o and the predicted p data:

$$m(o)_t = \frac{\Delta L(o)}{\Delta t} = \frac{L(o)_{t+1} - L(o)_t}{[t+1]-t} \quad \text{and} \quad m(p)_t = \frac{\Delta L(p)}{\Delta t} = \frac{L(p)_{t+1} - L(p)_t}{[t+1]-t},$$

<u>Detrending/Indexing</u>:

Indexing removes the age-related growth trend from the measured growth data by dividing measured growth o by predicted growth p. This routine method is known as detrending in dendrochronology:

$$GI_t = \frac{m(o)_t}{m(p)_t}.$$

<u>Standardizaton</u>:

The residuals (GI_t) of the integrated exponential fit were then standardized. Standardization removes the high correlation between mean and variance:

$$SGI = \frac{GI_t - \bar{x}_I}{\sigma_I}.$$

The standardized growth index (SGI = relative growth rates) is a dimensionless measure of how growth deviates from the average trend, i.e. the predicted growth. Now we can directly compare growth rates of different specimens with each other and between old and young specimens.

<u>Master chronology</u>:

A master chronology or composite chronology of all specimens was established (Schöne, 2003). SGI time-series, chronologies of relative growth rates of all live-collected specimens were strung together. At each year the arithmetic mean and the 95% confidence level were calculated.

The new time-series represents the mean relative growth rates of 67 specimens. Most specimens of our collection were alive during the 1990s. Due to low sample sizes in the 1980s, only the last 12 years show

relatively narrow confidence bands. For this reason, we compared (regression analysis) only the relative growth values of last 12 years with environmental parameters.

SGI values of the period 1988-1999 were plotted versus summer temperatures (i.e., average temperatures of the months of June through September). As mentioned above, summer temperatures play a crucial role in annual increment width formation. If summer temperatures are low, annual increment widths are large; if summer temperatures are high, annual increment widths are smaller. The residuals of this plot were correlated with river water discharge volumes.

Results & Discussion I

Growth and temperature were negatively correlated. Especially, summer temperatures control annual increment width. A highly significant correlation was also found between freshwater influx and growth. Little freshwater flow reduces the salinity slightly and increases growth rates. In turn, we can use SGI values to reconstruct summer temperatures and salinity. Approximately 35% of the variability in growth rate is significantly ($p<0.05$) explained by summer temperature variability; 26 % by salinity fluctuation.

A multiple regression of growth, water temperature and freshwater influx gave the best results: 71% of the variability in annual growth rates is significantly explained by a combination of both environmental parameters.

Methods II

In a further step, we used the detrended and standardized growth increment width time-series of dead-collected specimens (i.e., of specimens without known dates of death) and cross-dated them with the existing master chronology. Here, the use of gaping shells facilitates the cross-dating, because valves usually disarticulate within a few years of death. A series of different cross-dating techniques was employed to approach this goal. Visual comparison (Pointer-year method; Schweingruber et al., 1990) analyzes distinct growth patterns in two chronologies. Other tests compare, e.g., running similarity between two chronologies (Huber, 1943; Eckstein & Bauch, 1969). If, at a given year, growth increases in one chronology and decreases in the other one, then there is no similarity and vice versa. The combination of a series of different cross-dating tests is recommended when the chronologies are short. Regression analyses were conducted (SGI, summer temperatures and salinity).

Results and Discussion II

When compared to temperature and freshwater influx, the new chronology including the dead-collected ones indeed reveals slightly better results: now, 76% of the variability in growth rates is explained by water temperature and salinity.

Cross-dating shells with overlapping life spans allows the extension of the master chronology further back in time, to reconstruct the year of death and hatching of shells without known dates of death, and to improve the explained variability in growth rates.

Conclusions

Building master chronologies from relative growth rates of many organisms with overlapping life spans allows continuous long-term reconstruction of environmental conditions. The precondition for this is that in any given year most specimens in similar habitats exhibit roughly similar growth responses (narrow 95% confidence bands of the *SGI* mean values).

The common annual growth response of the intertidal bivalve mollusk *Chione* is controlled by summer water temperature and salinity (freshwater influx). Growth rates increase as temperature rises or/and more freshwater reaches the habitat and lowers the salinity slightly.

In order to know which factors control the annual increment widths, intra-annual growth patterns must be known: growth temperature range, which months are most important for annual increment width formation. When is the growth rate at maximum?

In the future, shells from museum collections could be used to extend the length of the master chronology. Dead shells without exact sample dates could be pre-dated by independent age determination techniques. Absolute dating techniques provide an approximate time window and serve to eliminate shells that will not fit in the master chronology. Cross-dating shells with overlapping life spans allows the extension of the master chronology further back in time. Establishing master chronologies opens up new possibilities to reconstruct the environmental and climate history over time periods much longer than individual life spans.

Acknowledgements

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Paleontology field trip to Ensenada, Baja California, Mexico (along the coast between Tijuana and Ensenada)

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Most of the Baja California peninsula is almost uninhabited rugged terrain. This makes it difficult to access its natural wonders without a 4x4 vehicle and appropriate field equipment. However, even near the urban zones, it is possible to enjoy beautiful landscapes almost untouched by humans.

The aim of this field trip is to show some of the most accessible paleontological sites in northwestern Baja California following the main coastal road. We will stop in some Cretaceous to Pleistocene localities to take a look at the characteristics of the rocks and to explain the paleoecological significance of the fossils in the peninsula's history. At the same time, we will see and comment about spectacular landscapes, pristine vegetation and Indian shell middens. At the end of our journey, a delicious dinner is waiting for us at Haliotis Restaurant, with the warm hospitality of the Mexican people.

Some observations on shell middens from the Colorado River Delta area

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The Colorado River Delta is an economically attractive environment, with an abundance of fisheries, natural landscapes and endemic species occurring in the area. Like elsewhere in the Gulf of California coastal zone, shell middens are the evidence of earlier marine resource exploitation by aboriginal groups living in the delta area, which could be added as another attraction for educational purposes in the Biosphere Reserve. Around the Ciénega de Santa Clara there are some thin, scattered shell middens. One

of them was dated to 975 - 40 years B.P. Pottery and midden surface characteristics appear associated to the Hakataya, and more specifically to the Patayan branch (Schroeder, 1960). The most abundant species in the molluscan assemblage, *Chione cortezi,* indicates local gathering, because this species is restricted to the northern Gulf of California. In contrast with another shell midden located at Campo Cristina, south of San Felipe along the Baja California Gulf coast, radiocarbon dated 1269 - 45 years B.P., the surface archaeological traits are different, suggesting a different aboriginal group. Some recommendations are given in order to preserve these fragile archaeological sites.

Emerging associations: Evaluation of the "host-specificity paradigm" for sacoglossan opisthobranchs associated with introduced macroalgae

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On temperate European shores, the native stenophagous marine herbivore *Placida dendritica* (Alder & Hancock, 1843) associates with the green macroalga *Codium fragile* introduced from north Pacific shores. On Scottish coasts, adult specimens of *P. dendritica* collected from introduced hosts prefer to associate with and consume the introduced *C. fragile* ssp. *atlanticum* and ssp. *tomentosoides* to the native *C. tomentosum*, comparable to my previous reports on the sympatric slug *Elysia viridis* (Montague, 1804). On Irish west-coast shores, where the native algal hosts are common, significantly more *P. dendritica* on the shore associate with the native *C. tomentosum* than with the introduced hosts. *Elysia viridis*, however, disproportionately attacks the exotics, especially *C. fragile* ssp. *tomentosoides*. On temperate Australian shores, the native stenophagous marine herbivore *Placida aoteana* (Powell, 1937) associates with the introduced green macroalga *C. fragile* ssp. *tomentosoides* as well as with native congeners and conspecifics. *Placida aoteana* is common and its herbivory evident in Port Phillip Bay, Victoria, and on both sides of Bass Strait. Slugs collected from native *C. fragile* exhibit no preference between algal subspecies in Victoria but a strong preference for introduced ssp. *tomentosoides* in Tasmania. Seasonal slug recruitment to available hosts coupled with an apparent flexibility in host use indicates that stenophagous marine herbivores can rapidly respond to introduced hosts on ecological time scales. Thus, the implicit peril of the host-specificity paradigm–that specialists could change their association–does occur in these stenophagous sacoglossan herbivores.

Depth–related adaptations, speciation processes and evolution of color in the genus *Phyllidiopsis* (Mollusca, Nudibranchia)

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The nudibranch genus *Phyllidiopsis* (Phyllidiidae) contains 30 currently recognized species, all of them distributed throughout the tropical Indo-Pacific, eastern Pacific, northwest Atlantic and Caribbean Sea (Gosliner & Behrens, 1988; Brunkhorst, 1993; Valdés & Ortea, 1996; Valdés, 2001). Half of the known species of *Phyllidiopsis* inhabit deep waters, and most of the deep-sea species of the Phyllidiidae belong to this genus. There is not a definitive explanation for the high diversity of *Phyllidiopsis* in the deep-sea, and whether this could be related to particular adaptations of this group or to historical reasons.

In light of phylogenetic analysis, several cases of vicariance are detected in this genus. Apparently two major vicariant events occurred between the tropical Indo-Pacific region and the Atlantic - eastern Pacific area first and subsequently between the eastern Pacific and the Atlantic.

Vicariant events could also be involved in producing vertical distributional patterns in a few species of *Phyllidiopsis*. The scarcity of phyllidiids in the Atlantic Ocean may be explained by historical events, including isolation and subsequent extinction in shallow waters.

There is a mimicry species complex in *Phyllidiopsis*, including species with a bluish background color and several longitudinal black lines.

Several members of a clade probably acquired this coloration through common ancestry, but *P. gemata* is a similarly colored unrelated species, that probably acquired this coloration through convergent or parallel evolution. There is also a group of white species, lacking any other contrasting colors, that inhabit deep-waters. This coloration could constitute an adaptation to the deep-sea environment and not a mimicry complex. In this case, all species acquired this coloration through common ancestry.

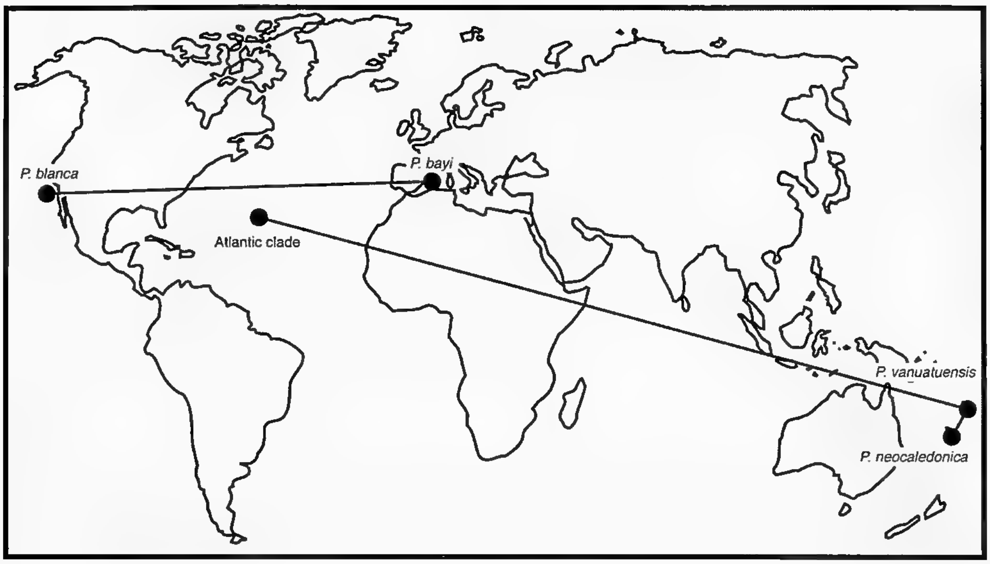

Figure 1. Vicariant events in *Phyllidiopsis*. Black dots mark the center of the geographic range of each species. Black lines join the center of the range of sister pairs of species.

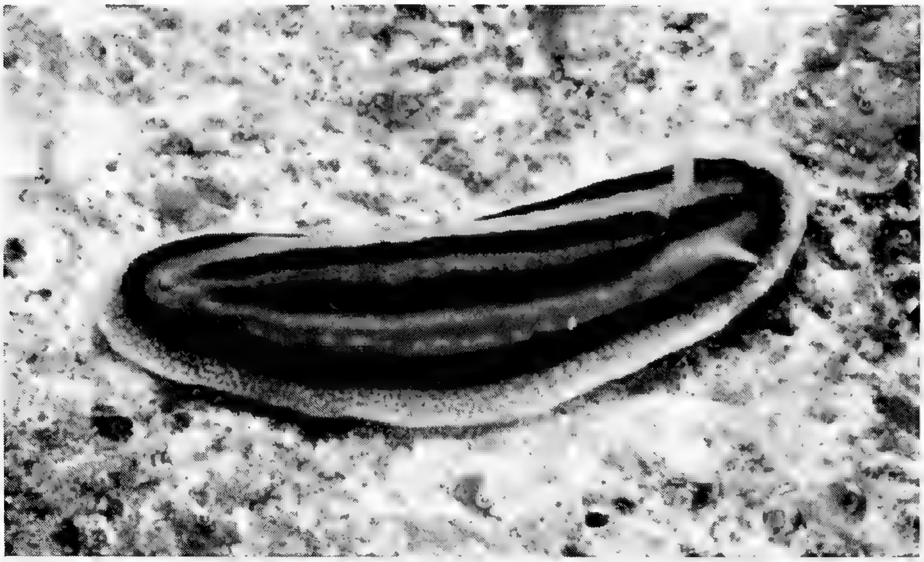

Figure 2. *Phyllidiopsis striata* from the Philippines, a species with a bluish background color with longitudinal black lines.

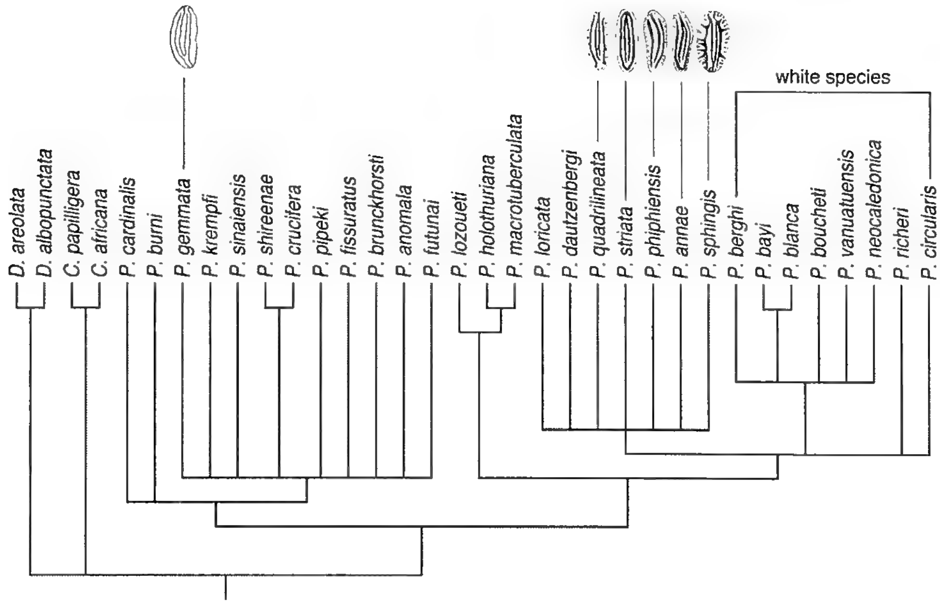

Figure 3. Strict consensus tree of *Phyllidiopsis*, after removing color characters. Species with a pattern of longitudinal black lines and their sister species are illustrated on the tree. Also, species with a white color background are marked.

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NOTE: The full version of this paper has been electronically published in Marine Biology, where it will appear in hard copy - http://link.springer.de/link/service/journals/00227/contents/01/00596/

Preliminary phylogenetic and taxonomic revision of the genus *Kaloplocamus* Bergh, 1892

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Described as *Euplocamus* by Philippi (1836), the genus was renamed as *Kaloplocamus* by Bergh in 1892. This genus is composed of 16 described species. These species are characterized by the presence of frontal and lateral ramified appendages, strong jaws with rods, presence (in most) of a rachidian plate and a feminine gland that envelopes the gametolytic gland. Three new species of *Kaloplocamus* from the Indo-Pacific (Papua, Palau, and the Philippines) are described as well as one new species from the deep sea. No parsimony-based phylogenetic analysis had been conducted to date for this group. Therefore, in this study we intend to examine the relationships between the different species in this genus by using a cladistic approach. Morphological and anatomical data from *Kaloplocamus* species were gathered both from direct observation and from the literature. The phylogenetic analysis demonstrates the monophyly of the genus *Kaloplocamus*.

Mussel fishery and culture in Baja California, Mexico

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The native mussel, *Mytilus californianus*, has been gathered for human consumption for centuries. Middens as old as 8,890 years have shells comprised of mussels, abalone, limpets, and snails. Fishermen have harvested *M. californianus* from rocky shores using simple tools. Landings reached a peak between 1968 and 1981, when average annual production was 430 metric tons. Most mussels were processed in

canneries. Two mussel species, *M. californianus* and the exotic *M. galloprovincialis*, now have good potential to be cultured in Baja California. The first attempts to culture both species were made in the 1970s. A company is now culturing *M. galloprovincialis*, using longlines 200 m long. Seed is collected on rope collectors, then attached to ropes at a rate of 2 kg per m, and hung on longlines. The seed is thinned after 1-2 months and is harvested for market at a length of 6-7 cm at 7-8 months. The culture has been fairly successful, but will require further development because of the exposed condition on the bays in Baja California. A recovery of *M. californianus* beds, an appropriate technology for *M. galloprovincialis* (using specific machinery), and the possibility of using *Modiolus capax* in the Gulf of California suggest a promising future for the mussel fishery.

Genetic variation in stenophagous sacoglossan herbivores on native vs. introduced algal hosts

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Coastal marine communities are being homogenized and degraded by introduced species such as the widely distributed, macroalgal pests *Codium fragile* ssp. *tomentosoides* and *Caulerpa taxifolia.* We are investigating genetic variation of the common sacoglossan sea slugs associated with native and introduced *Codium fragile: Placida dendritica* (Alder and Hancock, 1843). This species has been considered a single phenotypically variable species on temperate to boreal shores throughout the world, despite considerable evidence that it may be a complex of sibling species. This uncertainly has hindered the understanding of marine specialist herbivores and the ecological and evolutionary processes driving their host-plant use.

We are investigating three major ecological questions: (1) Are sympatric conspecific slugs from different green algal host species genetically differentiated? (2) Do "conspecific" populations of *P. dendritica* from Pacific and Atlantic shores in the northern and southern hemispheres form a single widely distributed species or a complex of sibling species? (3) Are slugs feeding on the native, non-weedy subspecies of *C.*

fragile genetically differentiated from conspecifics on introduced conspecific hosts? We are using AFLP (Amplified Fragment Length Polymorphism) and mitochondrial sequencing techniques to quantify genetic diversity among sympatric and allopatric slugs on the same vs. different algal hosts. Using AMOVA (Analysis of Molecular Variance), we will determine the spatial scale at which most genetic variation occurs: locally between host species, regionally across ocean basins and/or hemispheres, or globally between oceans.

ADDENDUM

Field trip: Paleontoloty in northwestern Baja California

Miguel A. Tellez Duarte and Hans Bertsch

Introduction

The peninsula of Baja California is primarily formed of sedimentary rocks, many of which are fossil bearing. In Baja California (the official name for the northern state in the peninsula is Baja California, not Baja California Norte) the following strata stand out for their importance: El Rosario, with its Cretaceous fauna of dinosaurs and gigantic ammonites; the marine mammals and sharks of the Miocene of La Misión; and the beautifully preserved molluscs of the Paleocene of San Carlos. There are also numerous other localities along both the Pacific and Gulf of California coasts. The geological age of these rocks spans from the Ordovician (between 438-505 million years ago) to the Pleistocene (2 million to 10,000 years ago). This large geologic history, as well as its main events, are summarized in Table 1.

Paleontological investigations in Baja California have been quite diverse, from taxonomic descriptions to paleoecological interpretations. Among the first published scientific works on the fossils of Baja California is the paper by White (1885), where a Cretaceous molluscan locality is described from Punta Banda. This locality is one of the sites that we will have the opportunity to visit in our field trip. Here we will be able to closely examine the excellently preserved Coralliochama orcutti, a rudistid bivalve whose strange shape adapted it to the reef environment.

It can be said that the pioneering work of White formally initiated the study of paleontology on the peninsula. The fossiliferous rocks with the oldest known ages date from the Ordovician (Miller, 1992). Nevertheless, rocks of the Paleozoic are quite rare, having been destroyed during the intrusion of the peninsular batholith, which are today visible as the granite mountain chains comprising the Sierras Juarez and San Pedro Mártir. Because of this event, the best-preserved records of fossiliferous rocks date from after the intrusion of the batholith at the end of the Cretaceous, and younger (less than 70 million years of age). The fossils which have been encountered are quite diverse, comprising a range from microscopic and macroscopic marine invertebrates, marine and continental vertebrates, and plants (Tellez, 1992).

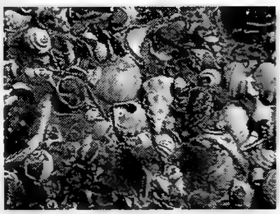
ERA	PERIODS	EPOCHS	IMPORTANT EVENTS IN BAJA CALIFORNIA
Cenozoic	Quaternary	Holocene 0.01 my	Man arrives to Baja California. Pleistocene megafauna extinction. Coastal shell indian middens.
		Pleistocene 1.6 my	Mammoths, camels, horses and other continental mammals in the Colorado River Delta and Pacific coast.
	Tertiary	Pliocene 5.3 my	Pectinids very common with other molusks. Marine mammals abundant. Gulf of California opening.
		Miocene 23.7 my	Protogulf of California diatomites. Extensive volcanism. La Misión fauna flowering.
		Oligocene 36.6 my	Abundant marine mammals, sharks and bony fishes. Rivers flowing from Sonora at Valle de Las Palmas.
		Eocene 57.8 my	Giant foraminifera in south peninsula. Mollusks very common. Tropical conditions.
65 my		Paleocene	Abundant mollusks and sharks. Early horse *Hyracotherium* and some other terrestrial mammals
Mesozoic	Cretaceous		Ammonoids and other mollusks in shallow seas. Early Cretaceous rudists reefs. Dinosaurs at El Rosario.
	Jurasic		Radiolarian rich rocks in Península de Vizcaino
230 my	Triassic		Subduction zone in western paleo-Baja California. Shallow seas with conodonts , fussulins and the ammonite *Meekoceras*.
Paleozoic	Permian		Few evidences of Paleozoic rocks. Probably shallow seas with crinoids, brachiopos and corals
	Pennsylvanian		
	Mississippian		
	Devonian		
	Silurian		
	Ordovician		Oldest known fossils in Baja California. Conodonts.
600 my	Cambrian		

Table 1. Geologic time scale with the main events in the history of Baja California.
Of the macrofossils, the invertebrates are the most common, especially the molluscs. Among the Cretaceous fossils, the most spectacular are the ammonites, of which on this trip we will be able to observe a gigantic mold of Pachydiscus catarinae. The large size of this species makes up for the tremendous plundering and destruction of other fossil species of smaller sizes, but no less important, in various localities of the state of Baja California. We will also have the opportunity to examine other types of associated fossils named ichnofossils, of which only the footprints of their passing on the surface of wet sediments have been preserved.

The tourist corridor between Tijuana and Ensenada, in addition to its spectacular landscape, extensive areas of natural vegetation, interesting geology and fossiliferous deposits, presents along nearly the entire coastline numerous pre-Hispanic midden mounds. These are accumulations of molluscan shells that had been collected by the indigenous peoples primarily as food. Although the majority of them have still not been studied, the scarce information that has been obtained from them has demonstrated the importance that molluscs had as part of the diet and for the elaboration of artifacts in the daily lives of these people. During this excursion we will be able to observe some midden mounds, which can be confused with paleontological deposits of the Pleistocene.

Finally, it must be clearly noted that the Mexican laws prohibit the removal, collection and alteration of archaeological and paleontological sites without the express permission of the Instituto Nacional de de Antropología e Historia (INAH). Therefore, while enjoying the natural scenery of this trip we ask your help in respecting the actual condition of the sites we will visit today.

Itinerary

Kilometer:

0 International Border, Mexico-United States. Immediately upon crossing the international border we are in the valley of the Tijuana River. The flat plane contrasts with the hills which surround the river bed, and which we observe on the sides of the road heading toward the Playas de Tijuana. The hills are deltaic sediments composed of sands and conglomerates of the San Diego Formation. These were deposited in the ancestral Tijuana River during the Pliocene and Pleistocene.

9 Playas de Tijuana. To the west of the hills, in the direction of the sea, the Bullring and the Coronados Islands can be viewed. The flat plane is due to a Pleistocene sea terrace formed approximately 55,000 years ago.

10 Caseta de Cobro (Toll Plaza). This is one of three toll booths that we will encounter on the journey to Ensenada. There is also an alternative free highway, which has slower traffic.

15 First Stop: La Joya. The rocks exposed in this site correspond to the Miocene Rosarito Beach Formation and the Pliocene San Diego Formation. The Rosarito Beach Formation consists of volcanic tufa, overlain with basalts. The contact between them is separated by a reddish surface originally baked by a flow of basalts at a very high temperature. Overlying the basalts are the sands and conglomerates of the San Diego Formation. At certain places basally appear lenses extremely fossiliferous, mainly of coastal molluscs characteristic of sandy and rocky substrates. Also common are the bones of marine mammals and fishes, especially shark teeth. Ashby & Minch (1984) interpreted a paleoenvironment of littoral to sublittoral, based on the molluscan fauna. There exist two important components: an epifauna of the genera *Acanthina*, *Calliostoma*, *Cantharus*, *Olivella*, *Polinices*, *Tegula*, *Thais* and *Turritella*. The second is an infauna, characterized by *Acila*, *Anadara*, *Calyptraea*, *Chione*, *Chlamys*, *Dosinia*, *Protothaca*, *Siliqua*, *Spisula* and *Patinopecten*. This last genus is that which dominates the aggregate. The faunistic components indicate a dominant presence of cold waters, with some elements of hot waters such as *Calyptraea*. The vertebrates are represented by the great white shark, *Carcharodon megalodon*, as well as other sharks such as *Isurus*, *Carcharinus* and rays. In association have been found whale, dolphin, and sea lion bones. The presence of *C. megalodon* is the first published report of this extinct shark in the late Pliocene, related to the extant great white shark *C. carcharias* (Ashby & Minch, 1984).

19 San Antonio del Mar. The Pleistocene terrace at this site shows fossil molluscs overlain with indigenous shell middens. The molluscs are the most common fossils in this terrace, comparable to numerous sites along the entire Pacific coast. San Antonio del Mar is one of the few coastal sites where continental mammal fossils have been found. Especially interesting was the discovery of the remains of a mastodon skeleton, probably belonging to a new species of *Stegamastodon*.

27 Rosarito. A small tourist village, recently converted into the fifth “municipio” of Baja California.

35 Toll Booth. Second toll booth.

39 Volcanic Peak. The small and prominent hill to the east of the road is composed of columnar basalts. These were formed upon cooling of material found in the interior of the volcano, forming a plug, which became exposed upon the erosion of the softer volcanic material that it contained.

54 Medano Sand Dunes. This is the only field of sand dunes located along the highway to Ensenada.

69 Second Stop: La Misión. In this site it is possible to see how the Guadalupe Arroyo forms an estuary where its mouth empties into the sea. The canyon formed along its length cuts upon rocks of the Lower Cretaceous of the Alisitos Formation, Upper Cretaceous of the Rosario Formation, and Miocene of the Rosarito Beach Formation. The rocks of the Rosario Formation contain isolated fossiliferous lenses in which are spiral ammonites such as *Pachydiscus*, and straight-shelled forms such as *Baculites*, and bivalves such as *Acila*. The rocks of the Rosario Formation underlie the basalts of the La Misión Member of the Rosarito Beach Formation, which in turn underlie the tufas and diatomaceous sediments of the Los Indios Member of the same Formation. The Los Indios Member has been very prolific in Middle Miocene fossil molluscs, among which are *Anadara topagensis*, *Chione temblorensis*, and beautiful silicified samples of *Turritella ocoyana*. Nevertheless, the vertebrate fauna is most notable, containing marine mammals, birds, reptiles, body fishes, and elasmobranchs, among which are more than 30 species of sharks and rays. The Museo de las Californias del Centro Cultural Tijuana exhibits a replica of the skeleton of a new species of manatee which was found among these deposits. Another notable find is a new species of *Demostylus*, a strange amphibious mammal similar to the hippopotamus, which went extinct near the end of the Miocene. The heterogeneity of the faunistic components suggest the mixing of organisms of distinct environments, from near the coast to the ancient terrace. Particularly interesting is the finding of a fossil camel. Because of the paleontological importance of these deposits, access to this area is very restricted.

78 Jatay. This tourist complex is situated on top of one of the few indigenous midden mounds that have been studied in Baja California. Jatay means in the native language "Agua Grande," or "Big Water." The site yielded a notable collection of hundreds of pieces of lithic instruments, ornaments of shell and stone, as well as a female skeleton. Based on the evidence of the projectile points, apparently the site has an age of over 2000 years.

84 El Mirador. This is the best panoramic view of Bahía de Todos Santos and its two islands. From this point, the highway begins to descend from the basalts of the La Misión member of the Rosarito Beach Formation to the clastic (=fragmented) sediments of the Rosario Formation of the Cretaceous.

91 Outcroppings of the Rosario Formation. The sediments along the highway until Ensenada correspond to deposits of submarine fans and terrace. In some concretions it is possible to encounter molluscan fossils, wood fragments, and carbonized leaves of *Araucaria*. The irregularities and bad conditions along this portion of the highway is due to slippage of the hillsides.

98 San Miguel. This is the last toll booth on the scenic highway. In this site one can appreciate the impact of the landslides by the destroyed buildings on top of the hill to the left of the highway.

102 El Sauzal. This fishing port is situated upon Cretaceous rocks.

105 Third Stop: CETMAR. Behind the school one can find coastal outcroppings of the Rosario Formation. Along the length of the highway, we have observed facies of relatively deep waters. In this site, the sands and conglomerates correspond to coastal waters in which are found molluscan fossils such as *Glycymeris* and *Ostrea*, as well as echinoderm spines. The enormous mold of the ammonite *Pachydiscus catarinae* found here was most likely carried from more open waters. The most notable feature of this location is the abundance of features of bioturbance in the sandstones, which is common in very shallow waters.

110 Ensenada. The city is located inside Bahía de Todos Santos, discovered by Juan Rodríguez Cabrillo in explorations of California in 1542. Since then only a few communities of indigenous Kumeya'ay (the Pa-Tai) live in the region. The majority of the vestiges of the Pa-Tai have been destroyed by the growth of the city. There only remain some midden mounds along the coast, and some remnants in the building foundations of various constructions in the center of the city. After 1804, the permanent European settlements began with the cattle ranch of José Manuel Ruiz.

116 Transpeninsular Highway. The hills to the east consist of metavolcanic rocks of the Late Jurassic to Early Cretaceous, which also form the basement of the rocks of the Rosario Formation observed in Stop Three.

126 Valley of Maneadero. This fertile valley is surrounded by a Pleistocene terrace. In the surrounding regions are hot springs formed by the presence of the Agua Blanca Fault. The superficial trace of this fault can be observed along the southern side of the spine of the Punta Banda peninsula.

146 Fourth Stop: El Rincón. In this site we observe the excellent fossil outcroppings of the rudistid bivalve *Coralliochama orcutti*. The Cretaceous rocks where they are found are exposed along the coastal cliffs in rocks that have been deformed by the presence of the Agua Blanca Fault. Nevertheless, the fossils found are quite well conserved, and some of them have their valves joined. The rudistids are the dominant faunal element. They are characterized by being an extinct group of bivalves with one of the valves being conical as an adaptation to reef life. Associated with them are found the gastropods *Tympanotonos totiumsanctorum*, *Bennoistia pillingi*, *Nerita californiensis*, *Potamides* sp. and *Ampullina* sp, cf. *A. concipio*. In its totality, this fauna indicates a shallow hot water reef environment (Saul, 1970).

In the same area occurs another more diverse fauna of molluscs from a shallow sudtidal sandy bottom habitat along an exposed coast. The common species of bivalves are *Acila* sp., *Glycymeris veatchii*, *Ostrea* sp., *Meekia daileyi*, *Tellina* sp., and *Calva varians*. Among the more abundant gastropods are *Lysis* sp., *Euspira* sp., *Gyrodes* sp., *Lispodesthes rotundus*, *Biplica obliqua* and *Nonacteonina* sp. (Fairbanks, 1893).

At the top of the stratigraphic section on the edge of the cliff, one can appreciate an indigenous midden mound most probably from the La Joya cultural complex.

Fifth Stop: Restaurant Haliotis. We return to the city of Ensenada and have dinner at one of the best, although not most expensive, fish and seafood restaurants in Ensenada. Enjoy your meal and have a safe trip back to San Diego!

INTRODUCCIÓN

La península de Baja California en buena parte se conforma de rocas sedimentarias, muchas de las cuales son fosilíferas. En particular para el estado de Baja California (el nombre oficial del estado norte es Baja California, no Baja California Norte) destacan por su importancia las de El Rosario, por su fauna de dinosaurios y las gigantescas amonitas del Cretácico; los mamíferos marinos y tiburones del Mioceno de La Misión, y los bellamente preservados moluscos del Paleoceno de San Carlos, entre otras numerosas localidades tanto en la costa del Pacífico como del Golfo de California. La edad geológica de estas rocas comprende desde el Ordovícico (entre 438 y 505 millones de años) hasta el Pleistoceno (2 millones a 10, 000 años). Esta larga historia geológica, así como sus eventos principales se sintetizan en la Tabla 1.
Las investigaciones paleontológicas en Baja California han sido muy diversas, desde descripciones taxonómicas hasta interpretaciones paleoecológicas. De los primeros trabajos científicos publicados sobre sus fósiles se encuentra el de White (1885), donde se describe una localidad de moluscos del Cretácico en Punta Banda. Esta localidad será una de las que tendremos la oportunidad de visitar en este viaje de campo, y donde podremos examinar de cerca el excelente estado de conservación de Coralliochama orcutti, un bivalvo rudista de extraño aspecto adaptado a la vida arrecifal.

Se puede decir que del trabajo pionero de White se inició formalmente el estudio de la paleontología de la península. Se ha encontrado que las rocas fosilíferas más antiguas fechadas datan del Ordovícico (Miller, 1992). Sin embargo, rocas del Paleozoico son muy poco comunes por haber sido destruidas durante la intrusión del batolito peninsular, cuya expresión son las cadenas montañosas graníticas de las Sierras de Juárez y San Pedro Mártir. Por este evento, los registros mejor preservados de rocas fosilíferas datan después de la intrusión del batolito a finales del Cretácico y más jóvenes (menores a los 70 millones de años). Los fósiles que se han encontrado son muy diversos, comprendiendo desde invertebrados marinos microscópicos, macroscópicos y vertebrados tanto marinos como continentales, así como plantas (Téllez, 1992).

De los macrofósiles los invertebrados son los más comunes, particularmente los moluscos. Entre los fósiles del Cretácico los más espectaculares son las amonitas, de las cuales en este viaje podremos observar un molde gigantesco de *Pachydiscus catarinae*. El gran tamaño de esta especie a propiciado un tremendo saqueo y destrucción de otras especies de fósiles de tamaño mas pequeño, pero no menos importantes, en varias localidades del estado de Baja California. También tendremos oportunidad de examinar otros tipos de fósiles asociados denominados icnofósiles, de los cuales solo se han conservado las huellas del tránsito de los organismos por la superficie de sedimentos húmedos.

El corredor turístico Tijuana-Ensenada, además de su espectacular paisaje, extensas zonas con su vegetación natural, interesante geología y depósitos fosilíferos, presenta en prácticamente toda la zona costera numerosos concheros prehispánicos. Estos son acumulaciones de conchas de moluscos colectados por los indígenas principalmente como alimento. Aunque la mayoría de ellos aún no han sido estudiados, la escasa información que de ellos se ha obtenido ha mostrado la importancia que los moluscos tuvieron como parte de la dieta y para la elaboración de artefactos de la vida cotidiana. Durante este recorrido tendremos oportunidad de observar algunos concheros, los cuales pueden ser confundidos con depósitos paleontológicos del Pleistoceno.

Finalmente, hay que advertir que las leyes mexicanas prohíben la remoción, colecta y alteración de sitios arqueológicos y paleontológicos sin contar con permiso del Instituto Nacional de Antropología e Historia. Por ello, suplicamos su colaboración para disfrutar en este viaje los escenarios naturales y respetar su estado actual.

Itinerario

Kilómetro:

0 Línea Internacional México-EEUU. Justo al cruzar la línea Internacional nos encontramos en el valle del Río Tijuana. El escenario plano contrasta con las colinas que rodean su cauce y las cuales observaremos a los lados del camino en el trayecto a Playas de Tijuana. Las colinas son sedimentos deltaicos compuestos de areniscas y conglomerados de la Formación San Diego. Estos fueron depositadas en el Río Tijuana ancestral durante el Plioceno y Pleistoceno.

9 Playas de Tijuana. Al oeste de las colinas en dirección al mar se puede apreciar la Plaza de Toros y las Islas Coronado. El paisaje plano en dirección al mar se debe a una terraza del Pleistoceno de aproximadamente 55 000 años.

10 Caseta de Cobro. Esta es una de las tres casetas de cobro que encontraremos en el trayecto a Ensenada. Existe una ruta alterna libre con mayor carga de tráfico.

15 Parada 1 La Joya. Las rocas aflorantes en este sitio corresponden a la Formación Rosarito Beach del Mioceno y la Formación San Diego del Plioceno. La Formación Rosarito Beach consiste de tobas

volcánicas a las que sobreyacen basaltos. El contacto entre ambas se destaca por una superficie cocida de color rojizo originada por el flujo de los basaltos a muy alta temperatura. Sobreyaciendo los basaltos se encuentran areniscas y conglomerados de la Formación San Diego. En su parte basal localmente aparecen lentes extremadamente fosilíferos, principalmente de moluscos costeros tanto de sustratos arenosos como rocosos. También son comunes huesos de mamíferos marinos y peces, especialmente dientes de tiburón. Ashby y Minch (1984) interpretaron un paleoambiente litoral a sublitoral con base a la fauna de moluscos. Existen dos componentes faunísticos importantes: uno epifaunal por los géneros *Acanthina*, *Calliostoma*, *Cantharus*, *Olivella*, *Polinices*, *Tegula*, *Thais* y *Turritella*. El segundo infaunal caracterizado por *Acilia*, *Anadara*, *Calyptraea*, *Chione*, *Chlamys*, *Dosinia*, *Protothaca*, *Siliqua*, *Spisula* y *Patinopecten*. Este último género es el que domina el conjunto. Los componentes faunísticos indican dominantemente la presencia de aguas frías, con algunos elementos de aguas cálidas como *Calyptraea*. Los vertebrados están representados por el gran tiburón blanco, *Carcharodon megalodon*, así como otros tiburones como *Isurus* y *Carcharinus* además de rayas. Asociados se han encontrado huesos de ballenas, delfines y leones marinos. La presencia de *C. megalodon* es el primer registro publicado de la presencia en el Plioceno Tardío de este tiburón extinto, emparentado con el actual gran tiburón blanco *Charcharodon carcharias* (Ashby y Minch, 1984).

19 San Antonio del Mar. La terraza del Pleistoceno visible en este sitio presenta fósiles de moluscos a los que sobreyacen concheros indígenas. Los moluscos son los fósiles mas comunes en esta terraza correlacionable en numerosos sitios a todo lo largo de la costa del Pacífico. San Antonio del Mar es uno de los pocos sitios costeros donde se han encontrado fósiles de mamíferos continentales. Particularmente interesante fue el hallazgo de los restos de un esqueleto de mastodonte *Stegamastodon*, el cual probablemente pertenezca a una especie nueva.

27 Rosarito. Pequeño poblado turístico recientemente convertido en el quinto municipio de Baja California.

35 Caseta de cobro. Segunda caseta de cobro.

39 Cuello volcánico. La pequeña y prominente colina al oeste del camino se compone de basaltos columnares. Estos se formaron al enfriarse el material fundido en el interior del cuello del volcán formando un tapón. Al erosionarse los materiales volcánicos más blandos que los contenían quedaron expuestos como se aprecia en la actualidad.

54 Dunas de El Médano. El único campo de dunas localizado a lo largo de la carretera hasta Ensenada.

69 Parada 2 La Misión. En este sitio es posible ver como el Arroyo Guadalupe forma un estuario al desembocar en el océano Pacífico. El cañón formado a lo largo de su recorrido corta sobre rocas del Cretácico inferior de la Formación Alisitos, Cretácico Superior de la Formación Rosario y Mioceno de la Formación Rosarito Beach. Las rocas de la Formación Rosario contienen en lentes aislados fósiles de amonoideos espiralados como *Pachydiscus* y de concha recta como *Baculites*, además del bivalvo *Acila*. Las rocas de la Formación Rosario subyacen los basaltos del Miembro La Misión de la Formación Rosarito Beach, los que a su vez subyacen las tobas y sedimentos diatomáceos del Miembro Los Indios de la misma Formación. El Miembro Los Indios ha sido muy prolífico en fósiles de moluscos del Mioceno Medio, entre los que destacan *Anadara topagensis*, *Chione temblorensis*, y hermosos ejemplares silicificados de *Turritella ocoyana*. Sin embargo, la fauna más notable es la de vertebrados constituida de mamíferos marinos, aves, reptiles, peces óseos, y elasmobranquios, dentro de los cuales incluye mas de 30 especies de tiburones y rayas. En el Museo de las Californias del Centro Cultural Tijuana se encuentra en exhibición una réplica del esqueleto de una nueva especie de manatí obtenido de estos depósitos. Otro hallazgo notable es una nueva especie de *Demostylus*, un extraño mamífero anfibio semejante a los hipopótamos extinguido a finales del Mioceno. La heterogeneidad de los componentes faunísticos sugiere la mezcla de organismos de distintos ambientes, desde próximos a la costa hasta plataforma. Particularmente interesante es el hallazgo de un fósil de camello. Dada la importancia paleontológica de estos depósitos el acceso a la zona se encuentra restringida.

78 Jatay. Complejo turístico asentado en uno de los pocos concheros indígenas que se han estudiado en Baja California. Jatay significa en lengua indígena “Agua Grande”. El sitio proporcionó una notable colección de cientos de piezas de instrumentos líticos, ornamentos de concha y piedra así como un esqueleto femenino. Basados en la evidencia de las puntas de proyectil aparentemente el sitio tiene mas de 2000 años de antigüedad.

84 El Mirador. La mejor panorámica de la Bahía de Todos Santos y sus dos islas. A partir de este punto el camino comienza a descender de los basaltos del Miembro La Misión de la Formación Rosarito Beach a los sedimentos clásticos de la Formación Rosario del Cretácico.

91 Afloramientos de la Formación Rosario. Los sedimentos a lo largo de la carretera hasta Ensenada corresponden a depósitos de abanicos submarinos y de plataforma. En algunas concreciones es posible

encontrar fósiles de moluscos, fragmentos de madera y hojas carbonizadas de *Araucaria*. En todo este tramo lo irregular de la carretera se debe al continuo deslizamiento del terreno.

98 San Miguel. Ultima caseta de cobro de la carretera escénica. En este sitio se puede apreciar el impacto de los deslizamientos de terreno por las construcciones destruidas en lo alto de la colina al este.

102 El Sauzal. Puerto pesquero asentado sobre rocas del Cretácico.

105 Parada 3 CETMAR. Al fondo de la Escuela se encuentran afloramientos costeros de la Formación Rosario. A lo largo de la carretera observamos facies de aguas relativamente profundas. En este sitio las areniscas y conglomerados corresponden a aguas costeras en las cuales se encuentran fósiles de moluscos como *Glycymeris* y *Ostrea*, así como espinas de equinodermos. El enorme molde de la amonita *Pachydiscus catarinae* que se encuentra en este sitio debió haber sido transportado de aguas mas abiertas. Lo mas notable de esta localidad es la abundancia de estructuras de bioturbación en las areniscas, lo cual es común en aguas muy someras.

110 Ensenada. La ciudad se encuentra asentada dentro de la Bahía de Todos Santos, descubierta por Juan Rodríguez Cabrillo en sus exploraciones de California en 1542. Desde entonces sólo algunas comunidades de indígenas Kumiai denominados Pa-tai habitaban la región. La mayoría de los vestigios de los Pa-tai han sido destruidos por el crecimiento de la ciudad. Sólo queda algunos concheros en la costa, y algunos remanentes en los cimientos de varias construcciones en el centro de la ciudad. Desde 1804 se iniciaron los asentamientos permanentes con el Rancho ganadero de José Manuel Ruiz.

116 Carretera transpeninsular. Las colinas al oeste consisten de rocas metavolcánicas del Jurásico tardío al Cretácico temprano, las cuales forman el basamento de las rocas de la Formación Rosario observadas en la Parada 3.

126 Valle de Maneadero. Fértil valle rodeado por una terraza del Pleistoceno. En los alrededores existen aguas termales originadas por la presencia de la Falla de Agua Blanca, de la cual puede observarse su traza superficial a lo largo del espinazo de la península de Punta Banda al sur.

146 Parada 4 El Rincón. En este sitio se observaremos excelentes afloramientos fosilíferos del bivalvo rudista *Coralliochama orcutti*. Las rocas del Cretácico donde se encuentran están expuestas a lo largo de los cantiles costeros en rocas deformadas por la presencia de la Falla de Agua Blanca. Sin embargo, los

fósiles se encuentran muy bien conservados y varios de ellos aún con las valvas unidas. Los rudistas son el elemento faunístico más sobresaliente. Se caracterizan por ser un grupo extinto de bivalvos con una de sus valvas cónica como una adaptación a la vida arrecifal. Asociados a ellos se encuentran los gasterópodos *Tympanotonos totiumsanctorum*, *Benoistia pillingi*, *Nerita californiensis*, *Potamides* sp. y *Ampullina* sp. cf. *A. concipio*. En su conjunto esta fauna indica aguas someras cálidas arrecifales (Saul, 1970).

En la misma área ocurre otra fauna mas diversa de moluscos de un ambiente submareal somero de fondo arenoso en una costa abierta. Las especies de bivalvos mas comunes son: *Acila* sp., *Glycymeris veatchii*, *Ostrea* sp., *Meekia daileyi*, *Tellina* sp., y *Calva varians*. Entre los gasterópodos algunos de los mas abundantes son: *Lysis* sp., *Euspira* sp., *Gyrodes* sp., *Lispodesthes rotundus*, *Biplica obliqua* y *Nonacteonina* sp. (Fairbanks, 1893).

En el tope de la sección estratigráfica al borde del cantil, se puede apreciar un conchero indígena muy probablemente del Complejo cultural La Joya.

Parada 5 Restaurant Haliotis. Regreso a la ciudad de Ensenada y comer en uno de los mejores, pero no el mas caro, restaurant de pescados y mariscos en Ensenada. Buen provecho y feliz regreso a San Diego!

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Executive Board Meeting

Meeting of the Executive Board was held in the Balboa Room at the Ramada Inn and Conference Center, San Diego on 20 June 2001.

Meeting was called to order by President Hans Bertsch at 5:00 PM.

Attending: Hans Bertsch, Terry Arnold, Douglas Eernisse. George Metz, Sandra Millen, and Roger Seapy.

- Secretary Report - presented by Terry Arnold. Minutes were unanimously accepted.

- Treasurer Report – presented by Cynthia Trowbridge (included herein). Brief discussion of report was followed by unanimous approval as presented.

- Nominating Committee Report – slate of nominees for 2002 presented by Roger Seapy, Committee Chair: President - Christopher Kitting; First Vice President - Ángel Valdés; Second Vice President - Jorge Cáceres-Mártinez; Secretary - Terry Arnold; Treasurer - Cynthia Trowbridge; Members at Large - Terry Gosliner and George Kennedy.

  The slate of nominees was approved unanimously for recommendation at the Business Meeting.

- Student Grant Committee – committee report transmitted by Hank Chaney, Chair and presented by Hans Bertsch: a total of four student grant awards are recommended for 2001 (details given elsewhere in this report): Isabel Hyman ($750); Joanna Joyner ($500); Brian Ort ($1,000); and Amy Wethington ($1,000).

  The award recommendations were approved unanimously and recommended for presentation at the Business Meeting.

- 2002 Meeting – Chris Kitting summarized plans for the 2002 meeting to be held at the Asilomar Conference Center, Pacific Grove, including location, dates, and tentative symposia topics.

- 2003 Meeting – Ángel Valdés summarized preliminary plans for the 2003 meeting to be held at the Los Angeles County Museum of Natural History, inluding preliminary ideas for symposia topics.

Meeting adjourned at 6:15 PM

Respectfully submitted, Terry Arnold (Secretary)

Annual Business Meeting

The Annual Business Meeting was held in the Balboa Room, Ramada Inn and Conference Center, San Diego on 23 June 2001.

Meeting was called to order by President Hans Bertsch at 4:15 PM.

- Secretary Report – presented by Terry Arnold, Secretary. Following the presentation (see Treasurers Report herein), Bertsch asked for and received unanimous approval.

- Treasury Report – presented by Cynthia Trowbridge, Treasurer. Trowbridge reviewed the previous year's financial activities and answered several questions. Bertsch called for and received unanimous approval of the Treasurer's report as presented.

- Report of Nominating Committee – Roger Seapy, Chair of the Nominating Committee presented the slate of nominees for 2002: President - Christopher Kitting; First VP - Ángel Valdés; Second VP - Jorge Cáceres-Mártinez; Secretary - Terry Arnold; Treasurer - Cynthia Trowbridge; Members at Large - Terry Gosliner and George Kennedy.

  Bertsch asked if there were any additional nominees. None were offered and Bertsch called for a vote of approval for the slate of nominees. Approval was unanimous.

- Student Grant Committee – Bertsch read the report prepared by Hank Chaney that included the names, titles and amount of the awards recommended by the Student Grant Committee for funding. (This information is included elsewhere in this report.) Bertsch called for approval of the Student Grant Committee report. Approval was unanimous.

- 2002 Annual Meeting – Chris Kitting, First Vice-President, presented an overview of plans for the 2002 meeting to be held 20-24 July at the Asilomar Conference Center, Pacific Grove. Kitting described the facilities, housing and dining options at the Asilomar Conference Center, and preliminary symposium convenors and topics.

- 2003 Annual Meeting – Ángel Valdés, Second Vice President, briefly presented his tentative plans for the 2003 meeting to be held at the Los Angeles County Museum of Natural History, Los Angeles in early June, including early ideas for symposium topics.

- New Business: Bertsch opened for discussion three topics - membership of the society in UNITAS, the question of "gratis memberships", and the problem of "dues in arrears". A lively discussion ensued, but no motions for action on these issues were raised.

There being no further business, the meeting was adjourned at 5:20 PM.

Respectfully submitted, Terry Arnold (Secretary)

TREASURER'S REPORT

5 December 2000 – 30 September 2001

INCOME

Membership Dues *		
Dues 1999	$15.00	
Dues 2000	111.00	
Dues 2001	1625.17	
Dues 2002	21.00	
Dues 2003	6.00	
Total		$1778.17
Student Grant Donations *		
WSM Auction/Reprints	1294.75	
AMS/WSM Auction	745.50	
Santa Barbara Malacological Soc.	500.00	
Southwestern Malacological Soc.	500.00	
San Diego Shell Club	300.00	
Northern California Malacol Soc.	150.00	
WSM Members	283.00	
Total		$3773.25
Symposium Fund Donations		179.00
Royalties		77.63
Meeting Income		6404.80
Interest Income		13.55
Total Income		$12226.40

EXPENSES

Administrative Costs		
Bank Charge	$55.39	
Mailing/Photocopying	92.79	
Total Administrative		$148.18
2002 Student Grants		3250.00
Annual Report 2000		
Printing Costs	$1443.73	
Mailing Costs	163.25	
Total Report Costs		1606.98
Meeting Expenses *		6754.90
Total Expenses		$11760.06

Net change	466.34
Current Balance (10/1/01)	$7155.48

ASSETS

Savings (does not include all of current interest)	
CD 28667-10492 (matures 12/05/01)	3128.52
CD 28667-10389 (matures 7/01/02)	11227.50
Total Assets	$21511.50

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* Some dues for 2001, donations for 2001 student grant, and expenses for 2001 occurred after 30 September 2001.

Student Grant Activities

The following students are the recipients of the 2001 WSM Student Grant Awards:

Isabel Hyman, School of Biological Sciences, University of Sydney, Sydney, Australia
"Evolution of the semi-slug in Helicarionidae. 1. Is Helicoarionidae a monophyletic group?" - $750

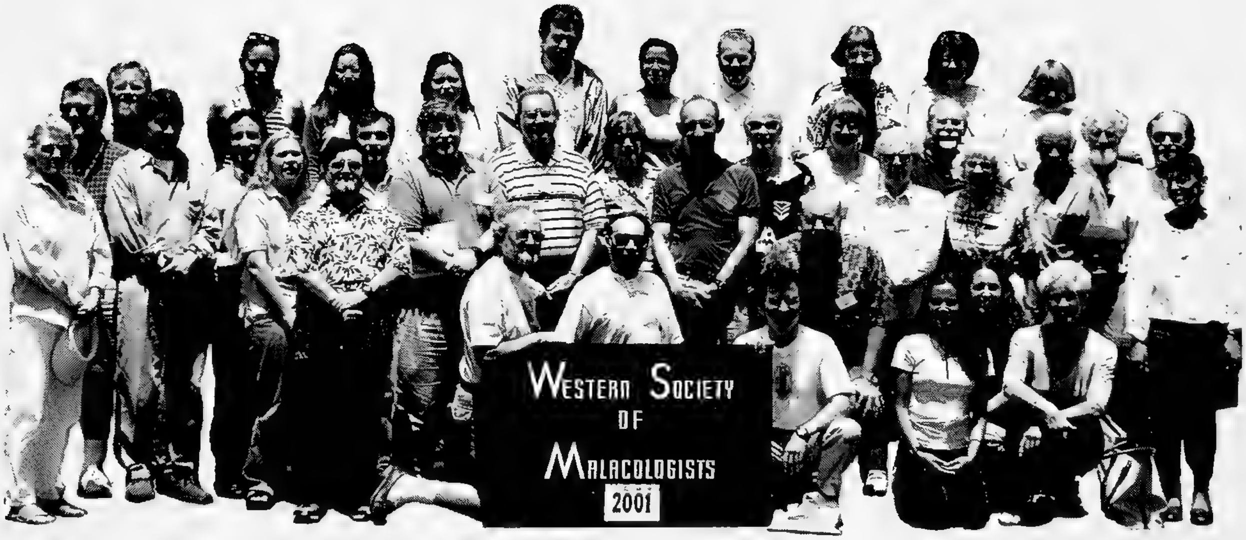
Joanna Lea Joyner, School of Biological Sciences, Washington State University, Pulman, WA
"Role of sulfur-containing amino acids in sulfide detoxification by marine mollusks" - $500

Brian S. Ort, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA
"A genetic approach to the study of the reproductive ecology of the California sea mussel, *Mytilus californianus*" - $1,000

Amy R. Wethington, Department of Biological Sciences, University of Alabama, Tuscaloosa, AL
"Phylogeny, taxonomy, and evolution of reproductive isolation in *Physa*" - $1,000

The Student Grants were made possible by the generous contributions of the following:

Individual donations from members of WSM
Northern California Malacological Club
San Diego Shell Club
Santa Barbara Malacological Society
Southwest Shell Club
Western Society of Malacologists



Rows are irregular and names are listed from left to right:

Row 1 (kneeling): Hans Bertsch, Chris Kitting, Ángel Valdés, Roger Seapy, Yolanda Camacho, Rebecca Johnson, Kirstie Kaiser

Row 2: Barbara Chaney, Miguel Tellez, Jorge Cáceres-Mártinez, Liz Hawkes, Ricardo Searcy, Miguel Angel del Rio, Terry Gosliner, Jules Hertz, Mary Jane Adams, Gene Coan, Carole Hertz, Sandra Millen, Margaret Mulliner, Mike Ghiselin, Charlotte Norris, Jim McLean, Clay Carlson, Lance Gilbertson, Edna Naranjo García

Row 3: Hank Chaney, Jeff Goddard, Marisela Aguilar Juarez, Iliana Espinosa Rodriguez, Rebeca Vasquez Yeomans, Sergio Guzman del Proo, Yvonne Valles, P.M. Johnson, Carole Hickman, Cynthia Trowbridge, Alice Monroe

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